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15 August 2012

Mr. Jonathan S. Davis
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SUBJECT: AFCEE FA8903-08-D-8769-0300; Task Order 0300
CDRL #A001k
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Dear Mr. Davis:

As directed by the Air Force Center for Engineering and the Environment, CH2M HILL is hereby distributing copies of the *Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum* dated August 2012. Enclosed are three bound copies, one unbound copy and three compact disc (CD) copies. Copies are also being sent to the appropriate agencies.

If you have any questions or comments, please contact Jon Davis at (508) 968-4670, extension4952.

Sincerely,

CH2M HILL

Patricia de Groot, P.G.
Program Manager

Enclosures: (3 bound & 3 CDs)

c: Rose Forbes, AFCEE/MMR (1 CD)
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Bob Lim, USEPA (1 bound, 1 CD)
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Massachusetts Military Reservation

Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

August 2012

Prepared for:
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Installation Restoration Program
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TABLE OF CONTENTS

TABLE OF CONTENTS

Figures

TABLE OF CONTENTS

Tables

Appendices

TABLE OF CONTENTS

ACRONYMS AND ABBREVIATIONS

AFCEE	Air Force Center for Engineering and the Environment
ANG	Air National Guard
AV	Ashumet Valley
BBM	Buzzards Bay Moraine
BBO	Buzzards Bay Outwash
bgs	below ground surface
BSVR	biosparging/vapor recovery system
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CLTMP	Comprehensive Long Term Monitoring Plan
COC	contaminant of concern
COPC	contaminant of potential concern
CS	Chemical Spill
CSM	conceptual site model
DoD	Department of Defense
EDB	ethylene dibromide
EPA	U.S. Environmental Protection Agency
FFA	Federal Facilities Agreement
FS	Fuel Spill
ft	feet/foot
FTA	Fire Training Area
GW-2	MCP Method 1 Groundwater-2
IRP	Installation Restoration Program
ITRC	Interstate Technology and Regulatory Council

ACRONYMS AND ABBREVIATIONS

LF	Landfill
LTM	Long Term Monitoring
MassDEP	Massachusetts Department of Environmental Protection
MCL	Maximum Contaminant Level
MCP	Massachusetts Contingency Plan
MMR	Massachusetts Military Reservation
MPP	Mashpee Pitted Plain
NJDEP	New Jersey Department of Environmental Protection
PCE	tetrachloroethene
PFSA	Petroleum Fuel Storage Area
RDX	hexahydro-1,3,5-trinitro-1,3,5-triazine
RI/FS	remedial investigation/feasibility study
ROD	Record of Decision
SD	Storm Drain
SPEIM	System Performance and Ecological Impact Monitoring
SWP	shallow well points
TCE	trichloroethene
USAF	U.S. Air Force
VI	vapor intrusion
VOC	volatile organic compound
1,2,4-TMB	1,2,4-trimethylbenzene
1,3,5-TMB	1,3,5-trimethylbenzene

1.0 INTRODUCTION

1.1 SITE AND REMEDIATION HISTORY

The Massachusetts Military Reservation (MMR) is located on western Cape Cod in Barnstable County, Massachusetts, approximately 60 miles south of Boston and immediately southeast of the Cape Cod Canal (**Figure 1-1**). It occupies approximately 22,000 acres within the towns of Bourne, Falmouth, Mashpee, and Sandwich. Military use of portions of MMR began as early as 1911. Most of the activity at MMR has occurred since 1935, including operations by the U.S. Army, the U.S. Navy, U.S. Coast Guard, U.S. Air Force (USAF), Massachusetts Army National Guard, Massachusetts Air National Guard (ANG), and the Veterans Administration.

Activities at MMR that have contaminated the environment have included the storage, handling, and disposal of solvents and petroleum fuels as well as the leakage of these materials into storm water drainage systems and the sanitary sewer system. Landfill operations, firefighter training, coal and ash storage, sewage treatment, and numerous chemical and fuel spills have also resulted in environmental contamination in both soil and groundwater (AFCEE 2008a).

Since 1990, the USAF Installation Restoration Program (IRP) has managed the characterization and remediation of the contamination at the MMR. The Comprehensive Environmental Response, Compensation, and Liability Information System number for the MMR site is MA2570024487. The MMR was formally added to the National Priorities List in 1989. A Federal Facilities Agreement (FFA), which provided the legal framework for investigating and remediating numerous operable units at the MMR, was signed in 1991 (EPA et al. 1991). In 1996, the FFA was amended to add the USAF as the lead agency for the cleanup at MMR (EPA et al. 2002). The FFA, as amended, requires the USAF to implement Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) requirements at MMR. In addition to the USAF, the U.S. Environmental Protection Agency (EPA) and National Guard Bureau are parties to the FFA for the MMR. The Air Force Center for Engineering and the Environment

(AFCEE) is managing the soil and groundwater contamination sites under the IRP in accordance with CERCLA as required by the Defense Environmental Restoration Program. The Massachusetts Department of Environmental Protection (MassDEP) is not a signatory of the FFA, but is an active participant in the cleanup process and provides guidance and direction to the process through several chartered boards and committees. The USAF and EPA have jointly selected the remedies for these sites. The MassDEP has concurred with the selected remedies (AFCEE 2008a, 2011a).

This screening level (i.e., first "phase") vapor intrusion (VI) evaluation has been completed to assess the potential for volatilization of site-related chemicals from the IRP groundwater plumes and also select areas where contaminated soil remains. The 16 IRP groundwater sites are shown on **Figure 1-2** and include: Ashumet Valley (AV), Chemical Spill-4 (CS-4), CS-10, CS-19, CS-20, CS-21, CS-23, Fuel Spill-1 (FS-1), FS-12, FS-13, FS-28, FS-29, Landfill-1 (LF-1), Fire Training Area-2 (FTA-2), Petroleum Fuels Storage Area (PFSA), and Storm Drain-5 (SD-5). Both soil and groundwater are evaluated at the PFSA and FTA-2 sites. The groundwater plumes associated with IRP Sites PFSA, FTA-2, SD-5 and FS-13 have largely attenuated, cannot be defined as contiguous groundwater plumes, and are therefore no longer depicted on IRP figures (i.e., **Figure 1-2**). However, the approximate location of the remaining residual contamination associated with each of these sites is shown on **Figure 1-2**.

The Records of Decision (RODs) that prescribe the final remedies for these sites are summarized in **Table 1-1**. All the sites addressed in this VI evaluation are in the Remedial Action – Operation or Long Term Monitoring (LTM) phases of the CERCLA process. The IRP groundwater plumes are defined as the extent of groundwater contaminated with the plume-specific contaminants of concern (COC) at concentrations above the applicable groundwater cleanup standards. Summaries of the groundwater plume COCs and the applicable groundwater cleanup standards are included in **Tables 1-2** and **1-3**, respectively. The cleanup standards included in **Table 1-3** are cited in the ROD for each respective site, as applicable. Further information regarding site background and the progress and status of the remedial actions for each of these sites is

included in documents referenced in **Table 1-1**, the *Final 3rd Five Year Review, 2002-2007 Massachusetts Military Reservation Superfund Site* (AFCEE 2008a), the primary site documents available in the Administrative Record and on the MMR IRP website at http://www.mmr.org/primarydocs/primarydocs.html and the *2010 Groundwater Plume Maps and Information Booklet* (available at http://mmr.org/cleanup/ 2010_booklet.html).

The groundwater plumes are currently being addressed through the operation of active remedial systems and/or through the processes of monitored natural attenuation. In addition, exposure to the groundwater contamination is being controlled through a Land Use Control program. The active treatment remedies generally involve pumping contaminated groundwater from the aquifer through a series of extraction wells, treatment through granular activated carbon to remove organic contaminants, and return of the treated water to the aquifer via injection wells or infiltration trenches. However, other active treatment technologies have been used, including biosparging/vapor recovery (BSVR) system at PFSA and biosparging at FTA-2. The locations of groundwater treatment facilities are shown on **Figure 1-2**. Source control and/or remediation have been carried out at identified source areas associated with the contaminant plumes (AFCEE 2008a).

Performance monitoring for the active remedial systems is conducted under the System Performance and Ecological Monitoring (SPEIM) Program. Sites with no active treatment are assessed under an LTM Program. Further details of these monitoring programs are available on-line in the *Comprehensive Long Term Monitoring Plan (CLTMP)* at http://www.mmr.org/CLTMP/default.htm.

1.2 PURPOSE OF THE SCREENING LEVEL VAPOR INTRUSION EVALUATION

Vapor intrusion is defined as the migration of volatile chemicals from the subsurface into overlying buildings (Interstate Technology and Regulatory Council [ITRC] 2007, EPA 2002). The presence of volatile organic compounds (VOCs) in soil, groundwater, or soil gas offers the potential for chemical vapors to migrate through subsurface vadose zone soils and/or along preferential pathways (such as underground utility lines), enter

buildings (e.g., via cracks in foundations), and impact the indoor air quality of these buildings.

The VI exposure pathway has been considered in the past in some of the risk assessments prepared for the IRP sites during the Remedial Investigation/Feasibility Study (RI/FS) phase of the CERCLA process. However, the most recent MMR CERCLA Five-Year Review (AFCEE 2008a) contained a recommendation to complete a more comprehensive and consistent VI evaluation for the various IRP groundwater plumes.

Due to the more recent increased regulatory focus on the VI exposure pathway and the advances in the science of VI, the potential for VI is being re-assessed for each of the IRP groundwater contaminant plumes and at the PFSA and FTA-2 sites where residual soil and groundwater contamination remains. This re-assessment for the groundwater-to-indoor air pathway initially involves determining whether there is a potentially complete VI exposure pathway associated with each groundwater plume. If a potentially complete VI exposure pathway is identified, a preliminary screening step is completed. The results of this screening step determine if further investigation is necessary to evaluate whether VI risk above target levels is likely or unlikely (AFCEE 2008a). Further details on the approach for assessing the potential for VI associated with the groundwater plumes is presented in Section 4.1.

At the request of AFCEE, the VI evaluation also includes gathering information relative to VOCs in the vadose zone at the PFSA and FTA-2 sites. This information is used to develop a VI conceptual site model (CSM) for each of these sites. The CSMs identify whether the potential for significant VI exists and whether additional investigation is needed. Further details on the approach for assessing the potential for VI associated with these two sites with residual soil contamination is presented in Section 4.2.

Note that this VI evaluation is intended to evaluate MMR-related contamination associated with the 16 IRP sites listed in Section 1.1. It is important to acknowledge that there may be other subsurface or aboveground contaminant sources that are unrelated to the IRP that may have a VI impact to an occupied building either on- or off-base.

1.3 DOCUMENT ORGANIZATION

This technical memorandum consists of seven sections and a series of appendices. Section 2 summarizes a generalized CSM for the IRP groundwater plumes as relevant to VI. Section 3 discusses prior VI evaluations completed as part of the CERCLA RI/FS process. Section 4 describes the VI evaluation methodology used in this assessment. Section 5 presents a summary of the results of the VI evaluation for each plume/site. Conclusions and recommendations are presented in Section 6, and references are included in Section 7. **Appendices A**, **B**, **C**, **D**, **E**, **F**, **G**, **H**, **I**, **J**, **K**, **L**, **M**, and **N** present detailed VI evaluation results for each of the groundwater plumes and **Appendix O** and **Appendix P** present VI evaluations for the PFSA and FTA-2 sites.

2.0 GENERALIZED CONCEPTUAL SITE MODEL FOR THE IRP GROUNDWATER PLUMES

This section presents an abbreviated CSM for the IRP groundwater plumes with a focus on the elements that are relevant to VI. Specifically, the subsections below provide details that support the following critical elements of the plume CSMs that play a role in this VI evaluation:

- The IRP plumes are large dissolved-phase groundwater plumes, with relatively low contaminant concentrations, located in a predominantly sand aquifer.
- In general, the IRP plumes have detached from their former source areas and the source areas are no longer contributing to groundwater contamination due to source area remedial actions completed by the IRP (AFCEE 2008a).
- Many of the plumes are now located off base and are migrating below land that is used for residential, limited commercial/industrial, agricultural, and recreational purposes.
- The groundwater plumes typically "dive" in the aquifer due to the regional groundwater flow field, resulting in the majority of the plume areas being in the deeper portions of the aquifer and overlain by a "lens" of clean groundwater.
- Some of the groundwater plumes rise in the aquifer when they reach their natural discharge points such as rivers, ponds, and the ocean.
- The majority of the IRP plumes are being remediated through the operation of groundwater pump and treat systems, however some plumes (e.g., CS-19) or portion of plumes (e.g., the off-base portions of LF-1) are being addressed through the processes of monitored natural attenuation.

A graphical representation of these elements of the groundwater plume CSM is presented on **Figure 2-1**. Further details of the site-specific CSMs can be found in the documents presented in **Table 1-1** and within the primary site documents available at http://www.mmr.org/primarydocs/primarydocs.html.

2.1 HYDROGEOLOGIC SETTING

An overview of the hydrogeological setting and MMR geology is presented below.

2.1.1 Geology

The unconsolidated sediment beneath the MMR and adjacent areas was deposited during late-stage Pleistocene glaciation. A majority of the MMR and the areas to the south between the MMR boundary and Vineyard Sound lie within a broad glacial outwash plain referred to as the Mashpee Pitted Plain (MPP). The western portion of the MMR is within and beneath the Buzzards Bay Moraine (BBM) and the Buzzards Bay Outwash (BBO). The ground surface topography is undulating but is generally flat with limited impervious surfaces, resulting in a large percentage of precipitation infiltrating to the vadose zone rather than running off. Surface topography throughout the MMR and surrounding areas is shown on **Figure 2-2**. The BBM is present as a veneer of bouldery glacial till overlying stratified sands and silty glaciolacustrine sediment. The sediments comprising the BBM and BBO are comprised primarily of fine- to coarse-grained sands, with generally laterally discontinuous fine-grained units (very fine-grained sands, silts, and clays). The MPP is comprised of poorly graded, medium- to coarse-grained sand with well-graded gravel, and occasional local, discontinuous lenses of fine-grained silty sands, silts, and clays. In areas, the MPP, BBM, and BBO are underlain by basal till. This sequence of glacial deposits above the till ranges in thickness from 70 feet (ft) near the Cape Cod Canal to the north of the MMR, to approximately 300 ft beneath the MMR, to more than 400 ft along Vineyard Sound to the south (**Figure 1-1**). These glacial sequences are underlain by bedrock, described as granite or granodiorite.

2.1.2 Hydrogeology

The single groundwater flow system that underlies western Cape Cod, including the MMR, is known as the Sagamore Lens. This sole-source aquifer is primarily unconfined and is recharged by infiltration of rainfall and snowmelt. Precipitation occurs at a rate of approximately 30 inches per year. Overall the predominantly sandy aquifer is considered homogenous and isotropic; locally, however, heterogeneous and anisotropic conditions occur. The surface terrain in the MMR area (and throughout Cape Cod) is pitted by many glacial kettle ponds. The kettle ponds are primarily groundwater fed and the pond levels fluctuate with the groundwater table.

In general, the depth to groundwater ranges from less than a few ft in areas near ponds, rivers, cranberry bogs, and saltwater bays/estuaries to up to approximately 85 ft below ground surface (bgs) below much of the MMR. To the west of the MMR, a groundwater depth of approximately 190 ft bgs has been recorded within the BBM. To the east of the MMR, in the vicinity of Snake Pond and the FS-12 plume, groundwater can be as deep as 90 ft bgs. To the south of the MMR, the depth to groundwater typically ranges from 40 to 80 ft bgs. Aquifer saturated thickness ranges from 230 to 320 ft bgs on base, 170 to 220 ft bgs to the west, 190 to 220 ft bgs to the east, and 150 to 250 ft bgs to the south. Water table elevations fluctuate both spatially and temporally with the largest fluctuation, up to 7 ft annually, typically observed at the groundwater mound located below the east central portion of the MMR (north of the FS-12 plume). Lesser seasonal water table elevation fluctuations are observed near the groundwater discharge points at the saltwater bays and estuaries to the west and south of the MMR. Groundwater flow direction in the Sagamore lens is generally radial from this groundwater mound. Therefore, since the IRP plumes, with the exception of CS-19, are located to the south of the groundwater mound, groundwater in the vicinity of the plumes flows west, southwest, south, and southeast. This radial groundwater flow pattern is reflected in the shape of the IRP plumes, shown on **Figure 1-2**. Flow direction within the aquifer is primarily horizontal, with stronger upward vertical gradients near surface water bodies such as the rivers, ponds, and bays.

2.2 GROUNDWATER CONTAMINATION

The IRP groundwater plumes identified at the MMR originated from identified or unidentified sources at or near the ground surface. For example, the AV plume originated from the former on-base FTA-1 and the former MMR Sewage Treatment Plant; and, although believed to be from an on-base fuel spill or release, the specific source of the FS-28 groundwater plume is unknown.

In general, the MMR plume constituents include chlorinated solvent compounds such as tetrachloroethene (PCE) and trichloroethene (TCE), fuel-related compounds such as ethylene dibromide (EDB), and explosives compounds such as hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX) in the case of the CS-19 plume.

These plume constituents originated from releases at their respective source areas. The materials released then migrated from the sources, percolated through the vadose zone, reached the groundwater table, and formed dissolved-phase contaminant plumes. Over time, the plumes migrated with groundwater away from the source areas and several are now located off base below residential, agricultural, recreational, and commercial areas (**Figure 1-2**). Contaminant concentrations within plumes have decreased over time due to source area cleanup, groundwater extraction and treatment, and through natural attenuation. Remediation systems have been successful at intercepting plumes or portions of plumes as they migrate and largely preventing them from migrating further toward downgradient surface water bodies. Overall, contaminant concentrations in the plumes are relatively low, and the plumes are located in the deeper portions of the aquifer; however, the areal extents of the plumes are relatively large as illustrated on **Figure 1-2**.

Most of the areal extent of the existing groundwater plumes is overlain by a lens of uncontaminated groundwater up to more than 100 ft thick where the plumes are located deep in the aquifer. The plumes generally dive in the aquifer and become overlain with uncontaminated water due to recharge accretion as the plumes migrate away from their source areas (**Figure 2-1**). In some instances, the groundwater plumes have reached their natural discharge points where they rise in the aquifer with the sub-regional groundwater flow and discharge to rivers, ponds, and the ocean.

3.0 PREVIOUS VAPOR INTRUSION ASSESSMENTS

As part of this evaluation, a review of the risk assessments contained in CERCLA RI/FS and ROD documents was completed for the 16 sites addressed in this document. **Table 3-1** is a matrix that summarizes the previously completed risk assessments, focusing on whether and how VI was evaluated, and including a brief description of the conclusions relative to VI. Documents are categorized in this matrix as follows:

1.) the VI exposure pathway was not considered or identified in the risk assessment;
2.) the VI exposure pathway was considered and identified as incomplete; or
3.) the VI exposure pathway was considered, identified, and further evaluated either qualitatively or quantitatively.

Although vapor inhalation resulting from potential exposure to pumped irrigation water, surface water, or household water was often considered in the risk assessments completed during the RI/FS phase of the CERCLA process, the VI exposure pathway from subsurface contamination into nearby buildings was not consistently considered. The VI exposure pathway was not considered at all for 11 plumes prior to this present evaluation. It was considered for five plumes/areas of concern but the VI pathway was found to be incomplete at four of these five plumes/areas of concern (**Table 3-1**).

The VI exposure pathway was quantitatively evaluated only at the AV plume. The Johnson and Ettinger Model was used to evaluate potential exposure to vapor-phase VOCs from groundwater through the subsurface into a residential dwelling. This model is a one-dimensional analytical solution to convective and diffusive vapor transport into indoor spaces and provides an estimated attenuation coefficient that relates the vapor concentration in the indoor space to the vapor concentration at the source of contamination in subsurface soil or groundwater. The model was run for several plume areas assuming a complete exposure pathway (i.e., no clean water lens and buildings were located nearby) and using the maximum concentration of each VOC detected in groundwater throughout the plume area considered, the average depth from the ground surface to the top of the water table in each plume area considered (approximately 30 ft bgs), and parameters for sandy soil. No risk above target levels associated with VI was

identified under this conservative approach (AFCEE 2007c). As noted in Section 1.2, the purpose of this effort is to complete a more comprehensive and consistent VI evaluation for the various IRP groundwater plumes including AV per the recommendation in the last MMR CERCLA Five-Year Review (AFCEE 2008a). The results of the prior VI work at AV will be considered in the re-evaluation that will follow the process described in this technical memorandum.

4.0 METHODOLOGY FOR VAPOR INTRUSION EVALUATION

This section describes the methodology that was used to conduct a screening evaluation of the potential VI exposure pathways associated with 16 IRP groundwater plumes and the two areas of contaminated soil (PFSA and FTA-2) shown on **Figure 1-2**. Potential VI from contaminated groundwater and soil are evaluated differently, partly due to the lack of available VI screening concentrations for soil. Methodology for VI analysis for groundwater plumes is described below, followed by methodology for VI analysis for soil at the PFSA and FTA-2 sites.

4.1 GROUNDWATER

The general approach for each groundwater plume is to: 1) determine whether there is a clean water "lens" overlying a groundwater contamination plume that prevents volatilization of contaminants from the water table; 2) determine whether occupied buildings are near plume areas not overlain by a clean water lens, and also determine whether preferential airflow pathways (defined below in Section 4.1.2), which could transport vapors to an occupied building further away than the default distance, are located near plume areas not overlain by a clean water lens; 3) if buildings or preferential pathways are nearby, determine whether the depth to groundwater is greater than 5 ft bgs and if dissolved concentrations (current and anticipated in the future) are low enough to infer that VI risks are unlikely to exceed target levels; and 4) if VI risks above target levels cannot be ruled out, recommend that a work plan for additional evaluation be developed. A decision diagram illustrating this approach is included as **Figure 4-1**. Each of these four steps, including their basis, is discussed in more detail in the following sub-sections.

4.1.1 Step 1: Determine Whether the VI Pathway May Exist

It is widely recognized that a layer of uncontaminated groundwater at the water table greatly impedes volatilization from contaminated groundwater to soil gas (ITRC 2007). Such a layer of uncontaminated groundwater is often referred to in the literature as a

"clean water lens" or "fresh water lens." There is debate over how thick the clean water lens must be in order to provide an effective barrier to volatilization.

MassDEP's standard operating procedure on indoor air contamination (MassDEP 2007) states that "Even a few feet of clean water overlying a dissolved VOC plume can prevent overlying impacts, given the very slow nature of liquid-phase diffusion." In addition, MassDEP guidance on petroleum contaminated sites (MassDEP 2002) states that "it may be useful to profile groundwater contaminant concentrations in the first 5 to 10 ft (using 1- to 2-ft intervals) of the saturated zone, to determine whether a clean water lens is present; however, the document does not recommend a lens thickness that would be considered adequate. MassDEP interim final VI guidance (MassDEP 2011) is silent on what constitutes a clean water lens.

New Jersey Department of Environmental Protection (NJDEP) VI guidance (NJDEP 2012) suggests 3 to 6 ft; i.e., if a 3-ft to 6-ft thick lens of groundwater with contaminant concentrations below NJDEP groundwater screening levels is present throughout the year, then significant off-gassing into the vadose zone is unlikely. Otherwise, additional investigation involving soil gas or indoor air sampling and analysis is recommended. However, the guidance contains caveats and states "If the clean water lens is at least three feet thick but less than 6 feet thick, perform periodic monitoring of the clean water lens thickness during seasonal low water levels (i.e., later summer to early autumn) to establish the minimum clean water thickness of three feet."

The Department of Defense (DoD) VI guidance (DoD 2009) was developed to support work on both active and closed USAF, Army, Navy, and Marine Corps bases. The DoD guidance cites the NJDEP value of 3 ft for a clean water lens as well as Rivett (1995), which suggests a similar thickness of 1 meter. Pursuant to the DoD guidance, 3 ft is used in this evaluation as the minimum year-round thickness for a clean water lens sufficient to prevent significant off-gassing from contaminated groundwater into the vadose zone.

Because of the uncertainties referred to in the NJDEP (2012) guidance, “clean” is defined herein as containing no detections of the MMR VI contaminants of potential concern (COPC) that are listed in **Table 4-1**. Laboratory reporting limits for the COPCs, as specified in the IRP program’s Quality Assurance Project Plan (AFCEE 2011b) are lower than their respective screening values shown in **Table 4-1**; therefore, current and past analytical procedures should provide data that meet the data quality objectives for this VI evaluation. The MMR VI COPCs are defined as MMR-related compounds having been detected in samples collected from site monitoring wells whose presence may require further VI evaluation. The groundwater plume COCs (presented in **Tables 1-2** and **1-3**), in contrast, are compounds that are present at concentrations above the respective groundwater cleanup criteria for a particular IRP contaminant plume. If there are detections of these VI COPCs (as applicable for each plume given the nature of the source[s]) within the top three feet of the saturated zone, a conclusion is reached that no clean water lens exists and the VI evaluation proceeds to the next step.

It is noted that the list of volatile compounds considered the MMR VI COPCs included in **Table 4-1** is more extensive than the list of groundwater plume COCs included in **Table 1-2**. The groundwater plume COCs were established based on the exposure assumptions developed during the risk assessment phase of the CERCLA process. These exposure assumptions typically consisted of ingestion of groundwater, dermal contact with groundwater or surface water, and inhalation of VOCs in groundwater used for household uses. As noted in Section 3.0, VI was not routinely considered in the risk assessments. Therefore, the list of MMR VI COPCs considered in this VI evaluation includes the detected volatile compounds that are believed to be related to past activities at the MMR. The list of VI COPCs presented in **Table 4-1** was developed based on a review of the available groundwater data in the MMR Data Warehouse.

Cross-sections that illustrate contaminant concentrations within each groundwater plume were evaluated for a preliminary determination of which (if any) portions of a plume may be without an overlying clean water lens. The certainty of determining the spatial distribution of contaminants is largely dependent on the vertical and lateral positioning of

available monitoring well screens. Some portions of some plumes may not have monitoring well coverage sufficient to demonstrate the presence (or absence) of a clean water lens with an adequate level of certainty. This characterization uncertainty is also dependent on the overall understanding in the groundwater flow field. In areas where a clean water lens is expected based on an understanding of the groundwater flow field and historic concentration trends both hydraulically upgradient and/or downgradient of those areas, but current monitoring data is lacking locally to conclusively demonstrate the clean water lens, additional data collection may be warranted at this point in the evaluation. Data collection can be accomplished, for example, through the sampling of existing wells (if available) or through the use of AFCEE's direct push drill rig.

This initial review of cross-sections is also designed to identify which plume areas should be evaluated further for the presence of a clean water lens year-round. Because water tables typically fluctuate over time, evaluation of cross-sections from one sampling round may not by itself be sufficient to demonstrate the year-round presence of a clean water lens. This phenomenon may be particularly important in hydraulically sensitive areas such as plume discharge points near rivers, ponds or bays. Because of the flat topography, permeable soil, lack of relatively large areas of impervious surfaces (such as asphalt and concrete), and thus high degree of recharge of precipitation (rather than runoff), significant portions of the MMR plumes are overlain by well over 3 ft of clean water. Because of the significant thickness of the clean water lens in these areas that is far in excess of groundwater elevation fluctuations, it is not necessary to evaluate variability in groundwater concentrations and elevations over time. However, in some specific areas, particularly near groundwater to surface water discharge points (e.g., near the saltwater bays), the clean water lens may be thinner and its thickness over time more sensitive to water table fluctuations. If the clean water lens in these areas near discharge points is near the 3-foot criteria, a more detailed assessment will be conducted with consideration of the overall hydrogeologic framework and assessment of historical data.

For those plume areas where a 3-ft thick clean water lens was demonstrated to be present over time, and is expected to remain present for the foreseeable future, it can be concluded that the VI pathway is incomplete. Therefore, concerns about VI are not warranted and no further evaluation was deemed necessary for these plume areas.

4.1.2 Step 2: Determine Proximity of Buildings Where Complete VI Pathway Exists

Off-gassing from any portion of a groundwater contamination plume not overlain by a clean water lens (as described above) has the potential to create a VI exposure if occupied buildings are nearby and if groundwater contaminant concentrations are sufficiently high. In Step 2, the proximity of potential receptors to the groundwater contamination is evaluated. A criterion is needed for specifying the distance beyond which significant VI would be considered unlikely, regardless of the magnitude of contaminant concentrations in groundwater and where a clean water lens is absent. VI guidance varies in this regard.

The Massachusetts Contingency Plan (MCP) (MassDEP 2008) recommends applying MCP Method 1 Groundwater-2 (GW-2) standards ("GW-2 standards" hereafter), which are used to assess potential VI from contaminants volatilizing from groundwater within 30 ft of a building if the annual average depth to water is 15 ft bgs or less. Beyond those distances, the MCP suggests that significant VI is considered unlikely in most, but not all, cases. The afore-mentioned interim final MassDEP VI guidance (MassDEP 2011) augments this GW-2 guideline by saying that if groundwater is not classified as GW-2 (i.e., is not within 30 ft of a building or does not have annual average depth to water of 15 ft or less), but is within 100 ft of a building and the groundwater contaminant concentrations are more than ten times the GW-2 standard, VI could occur and should be evaluated further. This change in MassDEP guidance may have been prompted by the discovery that groundwater beyond the GW-2 distance criteria (30 ft and 15 ft) can still lead to potential VI into buildings (Fitzpatrick and Fitzgerald 1996). The GW-2 distances were established before federal guidance documents were issued that present a more conservative approach in this regard. The proposed change in MassDEP guidance brings it more in line with federal guidance. The MassDEP interim final guidance also says that

GW-2 standards apply only when groundwater is the only source of contamination to indoor air (i.e., there is no contribution from contaminated soil).

Various federal guidance suggest that if any VI chemicals are present within approximately 100 ft, measured both horizontally or vertically, of an occupied building, VI should be evaluated in that area. For example, EPA draft VI guidance (EPA 2002) recommends that the possibility of VI be considered if volatile chemicals are suspected to be present in soil or groundwater within 100 ft in any direction of a building; this draft guidance does not apply to petroleum hydrocarbons, which tend to biodegrade and attenuate over shorter distances than non-petroleum chemicals. The ITRC guidance (ITRC 2007) cites and is in agreement with EPA (EPA 2002) in this regard and confirms the shorter attenuation distances for petroleum hydrocarbons. ASTM International's (ASTM 2010) standard for property transfer evaluations goes one step further in proposing an actual distance for petroleum hydrocarbons. This document says that if the lineal distance between the nearest edge of the contaminated plume and the nearest existing or planned structure on the target property, or between the nearest edge of the contaminated plume and the nearest target property boundary if there are no planned structures on the target property, is greater than or equal to 100 ft, or 30 ft for dissolved petroleum hydrocarbon chemicals of concern, then it is presumed unlikely that a potential vapor encroachment condition will exist in current or planned structure(s) on the target property. The critical distance for a petroleum hydrocarbon contaminated site where light non-aqueous phase liquid is present shall be the same as for non-petroleum hydrocarbon chemicals of concern (that is, 100 ft).

Environmental Security Technology Certification Program guidance (Environmental Security Technology Certification Program 2008) is also consistent with EPA (EPA 2002) in saying "nearby buildings" is commonly defined as within 100 ft of VOC impacts. Similarly, Air Force VI guidance (Air Force Institute for Operational Health 2006) recommends conducting a VI study if any listed volatile chemicals are detected within 100 ft of a building – horizontally or vertically. Later DoD VI guidance (DoD 2009), which supersedes the Air Force (Air Force Institute for Operational Health 2006)

guidance, cites EPA (EPA 2002) and goes on to say "Not all state health agencies agree that 100 feet is sufficient to prevent vapor migration and intrusion, so it is important to check with the local regulatory agency. Additionally, if preferential pathways exist in the subsurface that could facilitate the migration of chemicals towards a building, then the guideline of 100 feet may not be appropriate."

EPA draft guidance (EPA 2002) defines a "significant" preferential pathway as "a naturally occurring or anthropogenic subsurface pathway that is expected to have a high gas permeability and be of sufficient volume and proximity to a building so that it may be reasonably anticipated to influence vapor intrusion into the building. Examples include fractures, macropores, utility conduits, and subsurface drains that intersect vapor sources or vapor migration pathways." They can also include gravel lenses or channels, rodent tunnels, building sumps, drainage pits, dry wells connected to a basement, and sewer lines without vapor traps or traps that dried out or are no longer working properly (ITRC 2007). ASTM International (2010) says "Man-made preferential pathways may include, for example, utility conduits and sewers."

Based on the available guidance, for the purposes of this MMR VI evaluation, utilities considered to be preferential airflow pathways are limited to storm and sanitary sewer lines, septic system lines, industrial wastewater lines, water treatment plant influent and effluent lines (which may have been placed in permeable backfill), soil vapor extraction system lines, and water, electrical, and natural gas lines. The unconsolidated sandy soils at the MMR are not likely to include significant natural preferential airflow pathways because the vadose zone sediments consist of relatively homogeneous permeable sands with relatively few continuous silty or other fine-grained lenses.

This MMR VI evaluation assessed locations within 100 ft of groundwater containing VI COPC detections (**Table 4-1**) at any concentration and without an overlying 3-ft thick year-round clean water lens. These areas were evaluated for existing buildings and for significant preferential airflow pathways as defined above. The VI guidance documents do not include a threshold for "occupancy." Strictly speaking, if humans enter a building at any time, it could conceivably be considered an "occupied building." However, VI

screening values for unrestricted use (including GW-2 standards) typically and conservatively assume 24 hour-per-day, 365 day-per-year, 30-year occupancy.

Maps and MMR site personnel were consulted for information on the location of existing buildings and preferential pathways (as defined above) in the above-described evaluation areas based on the 100-ft distance criterion. If buildings or preferential airflow pathways were identified within 100 ft of groundwater containing detectable concentrations of VI COPCs which are not overlain by a 3-ft-thick clean water lens, the evaluation proceeded to the next step.

4.1.3 Step 3: Compare Groundwater Concentrations to VI Screening Values

For areas of concern without a demonstrable continuous clean water lens located within 100 ft of buildings or preferential airflow pathways (as defined above), VI COPC concentrations were compared with groundwater-to-indoor air screening values ("screening values" hereafter). The VI COPCs evaluated include all site-related compounds with the potential to volatilize and with sufficient toxicity to pose a risk. These include: the groundwater plume COCs (**Table 1-2**) that were identified in prior risk assessments (which are a number of VOCs as well as RDX), other site-related VOCs not necessarily identified as groundwater plume COCs, and extractable and volatile petroleum hydrocarbons in the case of the PFSA and FTA-2. Groundwater plume COCs that do not have the potential to volatilize (e.g., inorganics) were not evaluated. In addition, chemicals determined to be not related to the MMR site (e.g., methyl tertiary butyl ether, chloroform, and chloromethane) were not evaluated.

Table 4-1 lists the VI COPCs that were evaluated along with the corresponding MCP GW-2 standards (where available). **Table 4-1** also lists EPA groundwater screening values (from the 2002 draft guidance), which have been updated based on EPA's May 2012 Regional Screening Levels (EPA 2012) and that are generally conservative and considered to be protective of 90 percent of all structures. However, for a number of compounds (benzene, carbon tetrachloride, chlorobenzene, 1,4-dichlorobenzene, 1,2-dichloroethane, 1,1,2-trichloroethane, cis-1,2-dichloroethene, trans-1,2-

dichloroethene, 1,2-dichloropropane, ethylbenzene, TCE, vinyl chloride, and xylenes) the calculated risk-based screening values based on EPA's May 2012 Regional Screening Levels were lower than the Federal Maximum Contaminant Levels (MCLs), and the EPA 2002 guidance defaults to the MCLs for these compounds (**Table 4-1**). It is also noted that use of these groundwater screening values are only applicable if the depth to groundwater is greater than 5 ft below building foundation level (EPA 2002). If a complete VI exposure pathway is identified, and the depth to groundwater is less than 5 ft below building foundation level, the site cannot be ruled out for further VI evaluation based on groundwater screening values, and other site-specific investigation and evaluation must be undertaken.

Water table groundwater COPC concentrations (in areas without a clean water lens within 100 ft of buildings or preferential airflow pathways, and where the depth to groundwater is greater than 5 ft below building foundation level) were compared to both sets of screening values presented in **Table 4-1**. If groundwater concentrations were below both sets of the screening values presented in **Table 4-1**, groundwater was considered unlikely to result in VI risks above target levels. If groundwater concentrations of one or more VI COPCs were above both sets of screening values, additional evaluation of VI was deemed warranted. COPC concentrations in the "gray area," exceeding one screening value but not the other, prompted the review of multiple lines of evidence to evaluate whether the VI compounds detected in groundwater may be considered likely or unlikely to result in VI risks above target levels even though the lower of the two screening values for a compound(s) was exceeded. Lines of evidence include depth to groundwater, the presence of silty soil layers indicated by a review of boring logs, decreasing concentrations over time, compound biodegradability, and other factors.

To determine that groundwater is unlikely to result in VI risks above target levels on the basis of groundwater concentration data, concentrations need to be below screening values now but they also need to be expected to remain below these screening values in the future. Therefore, concentration trends over time were reviewed as necessary. In

addition, the evaluation also assessed whether groundwater containing COPCs that exceed the screening value that is currently overlain by a clean water lens is expected to flow into an area without a clean water lens in the future (see **Figure 4-2**). A third component of this step was to review assessment activities and source control measures that were undertaken to evaluate whether they were adequate. This involved determining if: 1) VI compound concentrations are below screening values; 2) VI compound concentrations are stable or decreasing; 3) more contaminated groundwater (above screening values) is not hydraulically upgradient of the location being evaluated; 4) sources have been adequately controlled; and 5) characterization data are deemed adequate, then the VI pathway can be considered insignificant and no further evaluation is deemed warranted.

4.1.4 Step 4: Recommend Additional VI Work for Areas Exceeding Screening Values

For those areas that : 1) are not overlain by a continuous 3-ft thick clean water lens; 2) are within 100 ft of buildings or preferential pathways; and 3) have groundwater VI COPC concentrations exceeding or expected to exceed EPA and MassDEP screening values, additional VI investigation is necessary. Additional investigation is also necessary if COPC concentrations are detected and the depth to groundwater is less than five feet below the building foundation, or if only one of the two screening values is exceeded and evaluation of multiple lines of evidence cannot rule out VI above target levels as unlikely. Additional VI investigation could include collection of soil gas samples and/or indoor air samples. Alternatively, options to address CSM/characterization uncertainty could include collection and analysis of additional groundwater samples from existing wells, additional groundwater sampling using the AFCEE direct push drill rig, and other activities that could refine the CSM for a particular groundwater plume and answer the question of whether the VI pathway is significant or not. Recommendations for additional VI work (as required) are included in Section 6.0 of this technical memorandum.

4.1.5 Summary of Approach

The general logic sequence of the evaluation approach is summarized below (and on **Figure 4-1**). Potential risks associated with the VI pathway for a given location are assumed to be insignificant as soon as the answer to one of the questions in the following sequence is "yes":

1. Is a clean water lens expected to be present for the rest of the life of the plume? If so, the VI pathway is incomplete and is anticipated to be incomplete in the future.
2. Are existing buildings and preferential airflow pathways absent within 100 ft of areas that lack a clean water lens? If so, the VI pathway is considered insignificant.
3. Is the depth to groundwater greater than 5 ft below the building foundation, are VI COPC concentrations stable or decreasing, have sources been controlled, are characterization data adequate, and are COPC concentrations below, and expected to remain below the two screening values (**Table 4-1**) for the expected life of the plume? (If only one of the two screening values is exceeded, can consideration of other factors such as depth to groundwater and soil characteristics lead to a conclusion that the risk of VI exceeding target levels is unlikely?) If the answers to these questions are "yes," the VI pathway is considered insignificant.
4. If the answer to any of the questions in Step 3 is "no," VI above target levels could be a risk for this location and additional VI investigation is warranted.

4.2 SOIL

The following presents the methodology used to evaluate two areas of contaminated soil (PFSA and FTA-2).

4.2.1 PFSA

Petroleum-related contamination is known to be present within 100 ft of occupied buildings at the PFSA. These buildings include Buildings 561 and potentially 587 (**Figure 4-3**). It is noted that Buildings 171, 172, and 173 have recently been demolished (February 2011) and are no longer of concern; furthermore, Building 196 is scheduled to be demolished during the summer of 2011 so will not be evaluated for VI. Soil contaminants are also present within 100 ft of preferential airflow pathways (as defined)

at the PFSA. The approximate extent of contamination at PFSA and the nearby buildings are shown on **Figure 4-3**. A conceptual schematic cross-section of the PFSA is shown on **Figure 4-4**. (A clean water lens is known to be absent in the immediate vicinity of the PFSA, therefore, one is not shown on **Figure 4-4**.)

There are no screening distances in the various guidance documents that can be invoked to definitively rule out VI concerns based on soil concentration data. Furthermore, there are no screening values for soil concentrations that may be used to screen out VI potential, and soil concentration data are not typically used in VI evaluations. One potential problem is that laboratory reporting limits and analytical detection limits for soil are often too high; even soil with VI compound concentrations below typical soil analytical detection limits has the potential to result in vapor-phase concentrations above VI target levels. A second challenge is that it is difficult to predict how soil contaminants would partition to soil gas due to variability in site-specific soil characteristics such as grading (or lack thereof), permeability, total porosity, water-filled porosity, and tortuosity. Thus, a lack of detected contaminants in soil does not necessarily imply the absence of VI issues.

The MassDEP interim final guidance (MassDEP 2011) says that if there is VOC contamination in the vadose zone adjacent to a building, i.e., within 6 ft horizontally or 10 ft vertically, potential VI should be further evaluated. The draft EPA guidance (EPA 2002) more conservatively states: "We recommend that an inhabited building generally be considered "near" subsurface contaminants if it is located within approximately 100 feet laterally or vertically of known or interpolated soil gas or groundwater contaminants…and the contamination occurs in the unsaturated zone and/or the uppermost saturated zone…The distance suggested above (100 feet) may not be appropriate for all sites (or contaminants) and, consequently, we recommend that professional judgment be used when evaluating the potential for vertical and horizontal vapor migration."

Groundwater at the PFSA will be evaluated as described previously in Section 4.1. Recent soil contaminant concentration data for PFSA are available. Following EPA draft guidance (EPA 2002), any detection of site-related volatile compounds in soil within 100 ft of a building or preferential airflow pathway prompted preparation of a CSM to guide further examination of the possibility of VI.

Information regarding the PFSA release, remediation, soils, hydrogeological setting, and presence of nearby buildings and preferential airflow pathways (as defined previously) were reviewed and synthesized into a preliminary CSM for the PFSA site as a whole. A CSM was then developed from this information for each nearby building that could potentially be subject to VI. If it was not possible to rule out VI as a potentially complete pathway in the PFSA groundwater plume area based on the criteria described above, the applicable groundwater information was incorporated into the CSM.

The purpose of the CSM is to gather and synthesize the information necessary to assess whether the VI pathway is likely to be significant. If existing information is insufficient to draw such a conclusion, the CSM will be used to help identify what additional information is needed and where. Additional information could include further assessment of existing data or development of new data through building inspection and collection and analysis of environmental samples. Environmental samples could include samples of sub-slab (or sub-basement) soil gas, exterior soil gas adjacent to the building, source area or preferential airflow pathway soil gas, indoor air, and/or ambient air (to evaluate outdoor background concentrations).

Information reviewed within the study area is described in **Appendix O**. Information relative to soil included assessment and remediation reports and recent concentration data from soil borings to establish the 100-ft area of investigation. Information relative to groundwater included the most recent groundwater sampling data from nearby monitoring wells; in addition, vapor sampling data from the BSVR system are also considered in the VI screening evaluation for the PFSA site. Information relative to buildings included construction plans for buildings within the 100-ft area of investigation and history of the use of the buildings. Information relative to preferential airflow

pathways included the location, construction, and history of the subsurface utilities (as defined previously) that are located within the 100-ft area of investigation.

4.2.2 FTA-2

In order to evaluate VI at the FTA-2 site, the same process was undertaken as outlined for the PFSA site above. The first steps in this area were to review assessment and remediation reports and contaminant concentration data from borings to establish the extent of residual contamination and the 100-ft VI assessment area. This area was evaluated for the presence of occupied buildings and potential preferential airflow pathways. The results of this evaluation for FTA-2 are included in **Appendix P**.

5.0 RESULTS

Detailed VI evaluations for the 16 individual contaminant plumes (including PFSA and FTA-2) listed in Section 1.1 are included separately as **Appendices A**, **B**, **C**, **D**, **E**, **F**, **G**, **H**, **I**, **J**, **K**, **L**, **M**, **N**, **O**, and **P**. These evaluations include supporting data, figures, and a narrative for each plume.

A summary of the findings from the 16 separate VI studies is included as **Table 5-1**. In addition, the following sections provide brief narratives summarizing the findings corresponding to each plume.

5.1 ASHUMET VALLEY PLUME

A review of groundwater monitoring data indicates that a constantly present clean water lens can be defined over most of the current extent of the AV plume south of Ashumet Pond. However, the available data do not indicate the presence of a clean water lens below the Backus River where groundwater discharges to the river and the plume COCs are detected in surface water. Additionally, a clean water lens cannot be defined with adequate certainty for the area immediately downgradient of the FTA-1 source area and in an area along the western shore of Ashumet Pond.

Within these areas, PCE has been detected in groundwater samples from wells screened at or near the water table. The locations of some of these wells combined with the absence of monitoring wells in certain areas leaves open the possibility that VI COPCs could be located within 100 ft of buildings or subsurface utilities.

However, in all of the cases where VI COPCs have been detected at the water table, the concentrations are below VI groundwater-to-indoor-air screening values. In addition, since no ongoing sources are present and long-term monitoring data indicate declining concentration trends throughout the AV plume, higher concentrations are not anticipated in the future. Therefore, the VI pathway is considered insignificant in these areas.

5.2 CS-4

A review of groundwater characterization and monitoring data collected at CS-4 indicates that a continuous clean water lens is present above the entire body of the CS-4 plume and is expected to be present in the future as long as the plume exists. Thus the VI exposure pathway at CS-4 is incomplete, and further evaluation of VI associated with the CS-4 plume is not necessary.

5.3 CS-10

A review of groundwater characterization and monitoring data collected at CS-10 indicates that a continuous clean water lens is present above the entire CS-10 plume and is expected to be present in the future as long as the plume exists, with the exception of the CS-10/FS-24 source area. Thus, for the majority of the CS-10 plume, the VI pathway is incomplete.

The CS-10/FS-24 source area has detectable concentrations of VI COPCs in groundwater at or near the water table within 100 ft of buildings. However, these VI COPC concentrations are below VI screening levels. In addition, contaminant sources have been adequately controlled, the area has been sufficiently characterized, and contaminant concentrations are stable or decreasing. Thus, the VI exposure pathway in this area is insignificant.

5.4 CS-19

A review of groundwater characterization and monitoring data collected at CS-19 indicates that a continuous clean water lens is present above the majority of the CS-19 plume and is expected to be present in the future as long as the plume exists. However, residual RDX concentrations are present at the water table below and near the CS-19 source area. Although a clean water lens does not exist below the CS-19 source area, no buildings or preferential airflow pathways are located in this area and future site development is controlled by on-base entities. Therefore, the VI exposure pathway at CS-19 is considered insignificant due to the absence of nearby receptors.

5.5 CS-20

A review of groundwater characterization and monitoring data collected at CS-20 indicates that a continuous clean water lens is present above the entire body of the CS-20 plume and is expected to be present in the future as long as the plume exists. Thus the VI exposure pathway at CS-20 is incomplete, and further evaluation of VI associated with the CS-20 plume is not necessary.

5.6 CS-21

A review of groundwater characterization and monitoring data collected at CS-21 indicates that a continuous clean water lens is present above the entire body of the CS-21 plume and is expected to be present in the future as long as the plume exists. Thus the VI exposure pathway at CS-21 is incomplete, and further evaluation of VI associated with the CS-21 plume is not necessary.

5.7 CS-23

A review of groundwater characterization and monitoring data collected at CS-23 indicates that a continuous clean water lens is present above the entire body of the CS-23 plume and is expected to be present in the future as long as the plume exists. Thus the VI exposure pathway at CS-23 is incomplete, and further evaluation of VI associated with the CS-23 plume is not necessary.

5.8 FS-1

A continuous clean water lens is present above the entire body of the FS-1 EDB plume downgradient of the source area and is expected to be present in the future as long as the plume exists. Thus the VI pathway is incomplete in this area. However, residual concentrations of toluene, ethylbenzene, and xylene are present at the water table below the FS-1 source area (located on-base). No buildings or preferential airflow pathways are located in this area and future site development is controlled by on-base entities. Therefore, the VI exposure pathway at the FS-1 source is area considered insignificant due to the absence of nearby receptors.

5.9 FS-12

A continuous clean water lens is present above the entire body of the FS-12 plume downgradient of the source area and is expected to be present in the future as long as the plume exists. Thus the VI pathway is incomplete in this area. However, residual fuel-related compounds are present at the water table below the FS-12 source area (located on-base). No buildings are located in this area and future site development is controlled by on-base entities. Underground utilities do exist in this area but are not considered viable conduits for vapor migration. Therefore, the VI exposure pathway at the FS-12 source area is considered insignificant due to the absence of nearby receptors.

5.10 FS-13

A clean water lens is not present at FS-13. VI COPCs in groundwater have not been detected within 100 ft of any buildings but have been detected within 100 ft of subsurface utilities. However, detected VI COPC concentrations at the water table are below VI screening values. In addition, 1,2,4-trimethylbenzene (1,2,4-TMB) and 1,3,5-trimethylbenzene (1,3,5-TMB) concentrations at FS-13 are stable or decreasing, sources have been controlled, and characterization data are adequate. Thus, the VI pathway is considered insignificant.

5.11 FS-28

A review of historic groundwater sampling data indicates that a constantly present clean water lens can be defined for the main body and the southern deep lobe of the FS-28 plume, thus further VI evaluation is not necessary for these areas. However, a clean water lens could not be defined with adequate certainty for the detached shallow plume lobe in the vicinity of the former shallow well point (SWP) system. Within that area, sporadic and isolated EDB detections have been observed near the water table, primarily below the western bog ditch, when investigated in 2008/2009. One residential structure is located approximately 100 ft west of this bog ditch. The EDB groundwater concentrations collected at or near the water table in 2008/2009 are less than the VI screening values. Therefore, the VI pathway is considered insignificant in this area.

Further VI evaluation for this area in the vicinity of the former SWPs is not necessary since EDB concentrations are expected to decline as the remnants of the plume naturally attenuate.

5.12 FS-29

A continuous clean water lens is present above the entire body of the FS-29 plume and is expected to be present in the future as long as the plume exists. Thus the VI exposure pathway at FS-29 is incomplete, and further evaluation of VI associated with the FS-29 plume is not necessary.

5.13 LF-1

A continuous clean water lens is present above the entire body of the LF-1 plume and is expected to be present in the future as long as the plume exists. Thus the VI exposure pathway at LF-1 is incomplete, and further evaluation of VI associated with the LF-1 plume is not necessary.

5.14 SD-5

A continuous clean water lens is present above the residual SD-5S related TCE and PCE detections and is expected to be present in the future as long as detections exist. However, a clean water lens is not present in the vicinity of the historic SD-5N plume. SD-5 related VI COPCs have been detected in groundwater at or near the water table within 100 ft of buildings and within 100 ft of subsurface utilities at SD-5N.

In all of the cases, detectable concentrations of PCE and/or TCE at the water table at SD-5N are below the VI screening values. Therefore, the VI pathway is considered insignificant in these areas. In addition, since no ongoing source of contamination is present and LTM data indicate declining concentration trends throughout the SD-5N area, higher concentrations are not anticipated in the future. Thus VI concerns are unwarranted based on either an insignificant (SD-5N) or incomplete (SD-5S) exposure pathway.

5.15 PFSA

Although surface and subsurface PFSA infrastructure have been removed or abandoned in place and several remedial actions have been implemented, residual soil and groundwater contamination remains at the PFSA. A review of recent groundwater data indicates that VI COPCs (specifically 1,2,4-TMB and 1,3,5-TMB) are present at the water table at concentrations above VI screening values.

Contaminated near-surface soil has been addressed through excavation in several areas and soil vapor extraction in one area to mitigate risks of dermal exposure to utility workers. Deeper contaminated soil at the capillary fringe has been remediated by BSVR to reduce this potential continuing source of groundwater contamination. Detectable concentrations of volatile petroleum hydrocarbon-related compounds remain in soil. Remediation was undertaken before VI became an issue in the site assessment and remediation industry; therefore, it is not clear if the soil contamination has been addressed sufficiently to mitigate VI risk.

In summary, while remediation has substantially improved site conditions, remedial actions were not designed to address VI risks, and VI risks cannot be ruled out based on this VI screening evaluation and further assessment of VI is warranted.

5.16 FTA-2

VI COPCs in soil are not located within 100 ft of any buildings but are located within 100 ft of subsurface utilities that could act as preferential airflow pathways. However, associated VI impacts are unlikely due to the relatively long travel distances between the soil VI COPCs and nearest buildings.

A clean water lens is not present at FTA-2. VI COPCs in groundwater have not been detected within 100 ft of any buildings; however, the monitoring network is insufficient to definitively rule out the presence of VI COPCs in groundwater within 100 ft of nearby buildings. In addition, VI COPCs in groundwater are located within 100 ft of subsurface utilities.

VI COPC concentrations exceed VI screening values at 10 wells. Three of these wells are located within 100 ft of subsurface utilities. However, VI impacts from the FTA-2 area groundwater are unlikely due to the nature of the utilities and the nearby buildings, relatively long travel distances involved, relatively small magnitudes of the VI screening level exceedances, and generally decreasing VI COPC concentrations in groundwater.

6.0 CONCLUSIONS AND RECOMMENDATIONS

The following sections summarize the conclusions and recommended actions at each site addressed by this VI evaluation.

6.1 ASHUMET VALLEY PLUME

No further monitoring or data collection is needed specific to VI. However, as part of the ongoing remedial actions at the AV plume, AFCEE will continue to monitor the nature and extent of the AV plume and will re-evaluate the VI exposure pathway if conditions change such that VI could be a concern.

6.2 CS-4

No further monitoring or data collection is needed specific to VI. However, as part of the ongoing remedial actions at CS-4, AFCEE will continue to monitor the nature and extent of the CS-4 plume and will re-evaluate the VI exposure pathway if conditions change such that VI could become a concern.

6.3 CS-10

No further monitoring or data collection is needed specific to VI. However, as part of the ongoing remedial actions at CS-10, AFCEE will continue to monitor the nature and extent of the CS-10 plume and will re-evaluate the VI exposure pathway if conditions change such that VI could become a concern.

6.4 CS-19

No further monitoring or data collection is needed specific to VI. However, as part of the ongoing LTM program at CS-19, AFCEE will continue to monitor the extent and attenuation of the CS-19 plume and will re-evaluate the VI exposure pathway if conditions change such that VI could become a concern.

6.5 CS-20

No further monitoring or data collection is needed specific to VI. However, as part of the ongoing remedial actions at CS-20, AFCEE will continue to monitor the nature and extent of the CS-20 plume and will re-evaluate the VI exposure pathway if conditions change such that VI could become a concern.

6.6 CS-21

No further monitoring or data collection is needed specific to VI. However, as part of the ongoing remedial actions at CS-21, AFCEE will continue to monitor the nature and extent of the CS-21 plume and will re-evaluate the VI exposure pathway if conditions change such that VI could become a concern.

6.7 CS-23

No further monitoring or data collection is needed specific to VI. However, as part of the ongoing remedial actions at CS-23, AFCEE will continue to monitor the nature and extent of the CS-23 plume and will re-evaluate the VI exposure pathway if conditions change such that VI could become a concern.

6.8 FS-1

No further monitoring or data collection is needed specific to VI. However, as part of the ongoing remedial actions at FS-1, AFCEE will continue to monitor the nature and extent of the FS-1 EDB plume, and the residual toluene, ethylbenzene, and xylene concentrations at the source area will be further evaluated during site closure activities. The VI exposure pathway will be re-evaluated if conditions change such that VI could become a concern.

6.9 FS-12

No further monitoring or data collection is needed specific to VI. However, as part of the ongoing remedial actions at FS-12, AFCEE will continue to monitor the nature and extent

of the FS-12 plume, and the residual fuel-related concentrations at the source area will be further evaluated during site closure activities. The VI exposure pathway will be re-evaluated if conditions change such that VI could become a concern.

6.10 FS-13

No further monitoring or data collection is needed specific to VI. However, as part of the ongoing remedial actions at FS-13, AFCEE will continue to assess the nature and extent of groundwater contaminants in the former FS-13 plume area and will re-evaluate the VI exposure pathway if conditions change such that VI could become a concern.

6.11 FS-28

No further monitoring or data collection is needed specific to VI at FS-28. However, as part of the ongoing remedial actions at FS-28, AFCEE will continue to monitor the nature and extent of the FS-28 plume and will re-evaluate the VI exposure pathway if conditions change such that VI could be a concern.

6.12 FS-29

No further monitoring or data collection is needed specific to VI. However, as part of the LTM program at FS-29, AFCEE will continue to monitor the nature and extent of the FS-29 plume and will re-evaluate the VI exposure pathway if conditions change such that VI could become a concern.

6.13 LF-1

No further monitoring or data collection is needed specific to VI. However, as part of the ongoing remedial actions at LF-1, AFCEE will continue to monitor the nature and extent of the LF-1 plume and will re-evaluate the VI exposure pathway if conditions change such that VI could become a concern.

6.14 SD-5

No further monitoring or data collection is needed specific to VI at SD-5. However, as part of the ongoing LTM program at SD-5, AFCEE will continue to monitor the attenuation of the residual TCE and PCE concentrations and will re-evaluate the VI exposure pathway if conditions change such that VI could be a concern.

6.15 PFSA

While remedial actions at PFSA have substantially improved site conditions, they were not specifically designed to address VI risks, and VI risks cannot be ruled out based on the VI screening evaluation presented in **Appendix O** for the following primary reasons:

- Groundwater contaminant concentrations exceed groundwater-to-indoor-air VI screening values within approximately 100 ft of occupied buildings.
- Volatile compounds have been detected in soil within approximately 100 ft of occupied buildings.

In accordance with the approach presented in this document, VI risk above target levels cannot be ruled out and additional VI evaluation is warranted. A work plan for additional VI assessment should be developed for the PFSA based on the VI CSM presented in **Appendix O**.

6.16 FTA-2

No further monitoring or data collection is needed specific to VI. However, as part of the ongoing LTM program at FTA-2, AFCEE will continue to monitor the extent and attenuation of the VI COPCs and will re-evaluate the VI exposure pathway if conditions change such that VI could become a concern.

7.0 REFERENCES

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FIGURES

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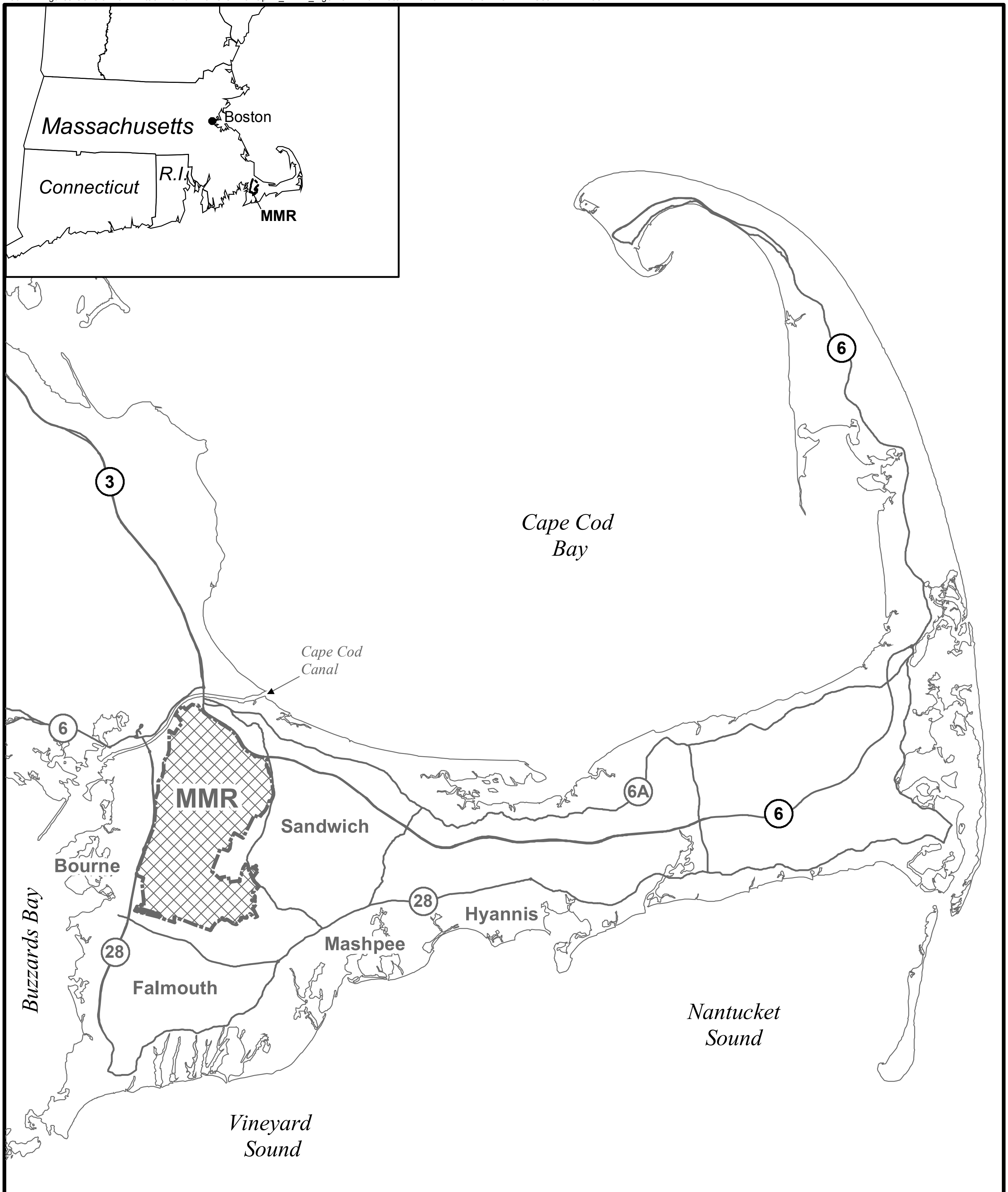

Data Source: AFCEE, MMR-AFCEE Data Warehouse
MMR Boundary from Massachusetts Air National Guard 2011

Legend

Massachusetts Military Reservation

0 3 6
Miles

FIGURE 1-1

MASSACHUSETTS MILITARY RESERVATION, CAPE COD, MASSACHUSETTS

Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

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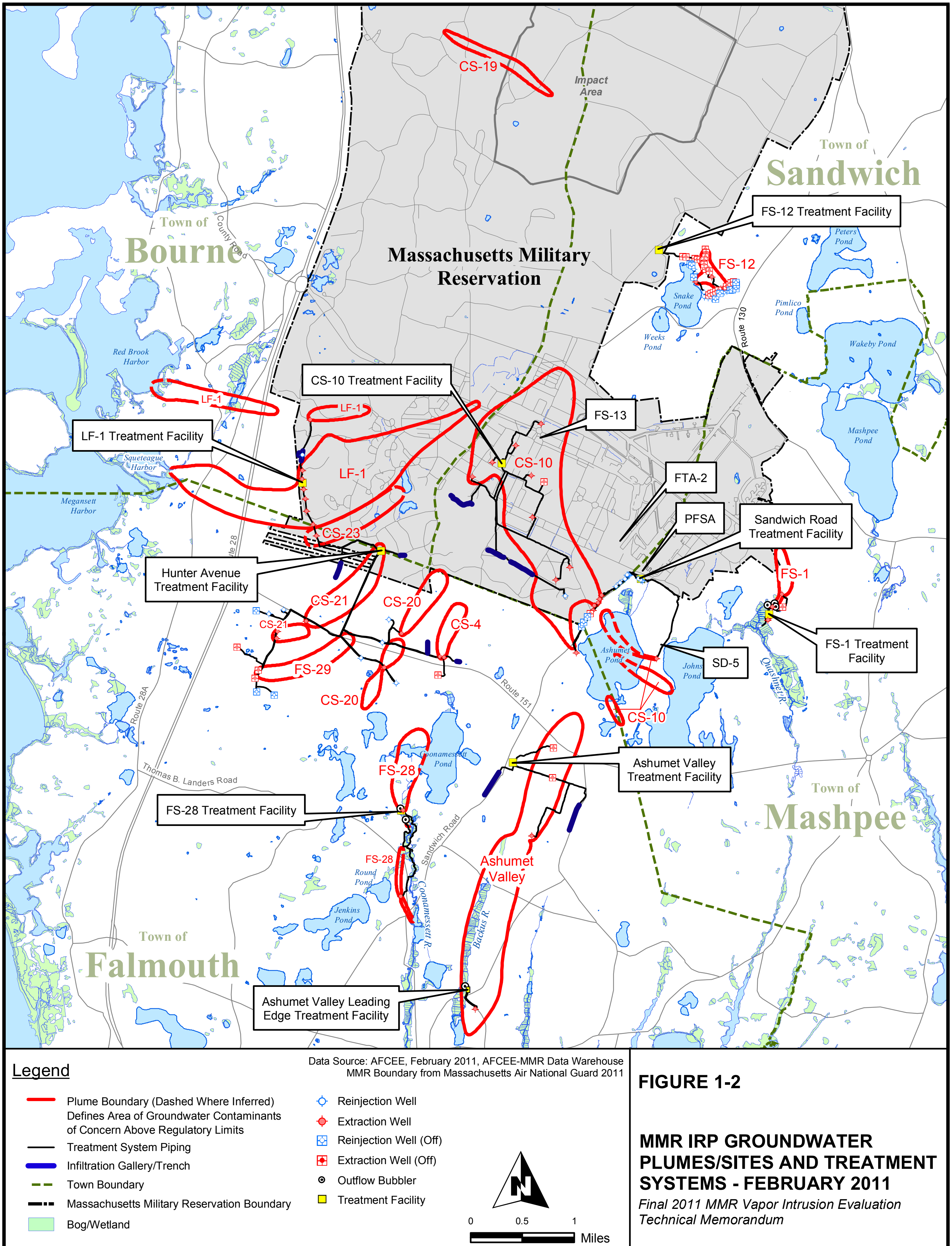

Data Source: AFCEE, February 2011, AFCEE-MMR Data Warehouse
MMR Boundary from Massachusetts Air National Guard 2011

FIGURE 1-2

MMR IRP GROUNDWATER PLUMES/SITES AND TREATMENT SYSTEMS - FEBRUARY 2011

Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

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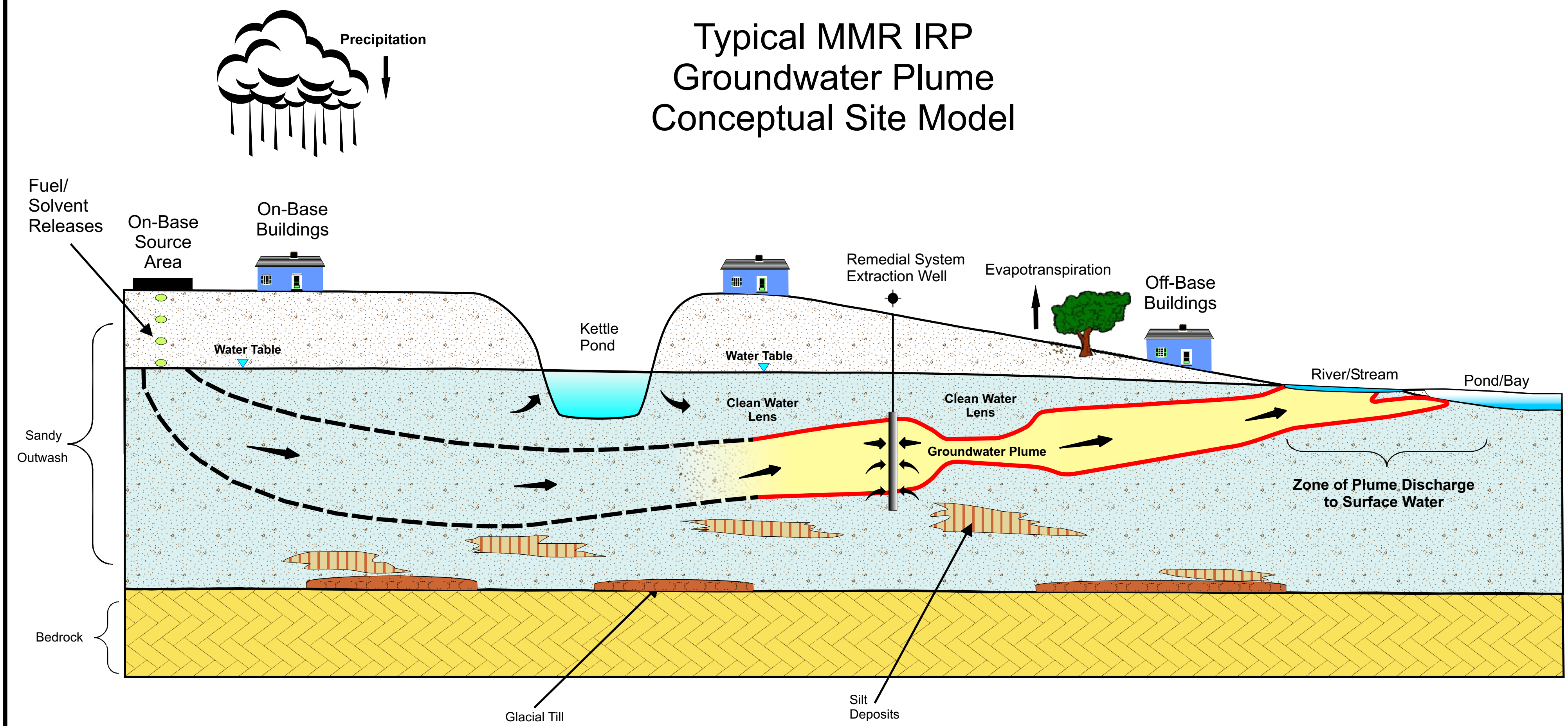

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	Extraction Well		Groundwater Flow
	Plume Depiction		
	Historic Plume Depiction		

Vertical Exaggeration
(not to scale)

FIGURE 2-1

CONCEPTUAL SITE MODEL FOR MMR IRP DISSOLVED-PHASE GROUNDWATER PLUME

AFCEE - Massachusetts Military Reservation

Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

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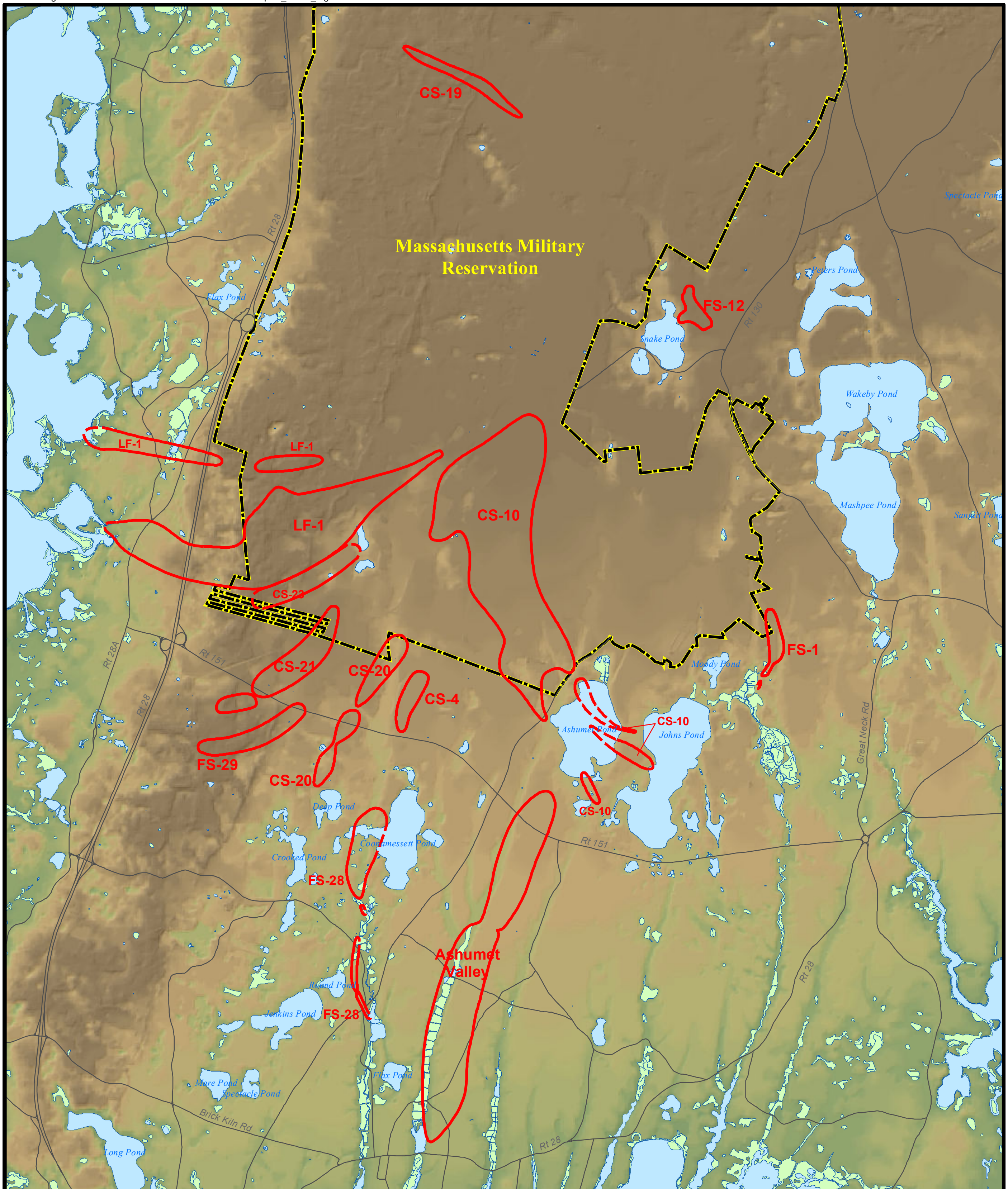

Legend

Terrain Elevation

Feet Mean Sea Level

(National Geodetic Vertical Datum of 1929)

High : 305

Low : 0

Massachusetts Military Reservation Boundary

Plume Boundary (Dashed Where Inferred)

Data Source: AFCEE, MMR-AFCEE Data Warehouse
MMR Boundary from Massachusetts Air National Guard 2011

0 0.5 1 Miles

FIGURE 2-2

MASSACHUSETTS MILITARY RESERVATION AREA TOPOGRAPHY

AFCEE - Massachusetts Military Reservation

Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

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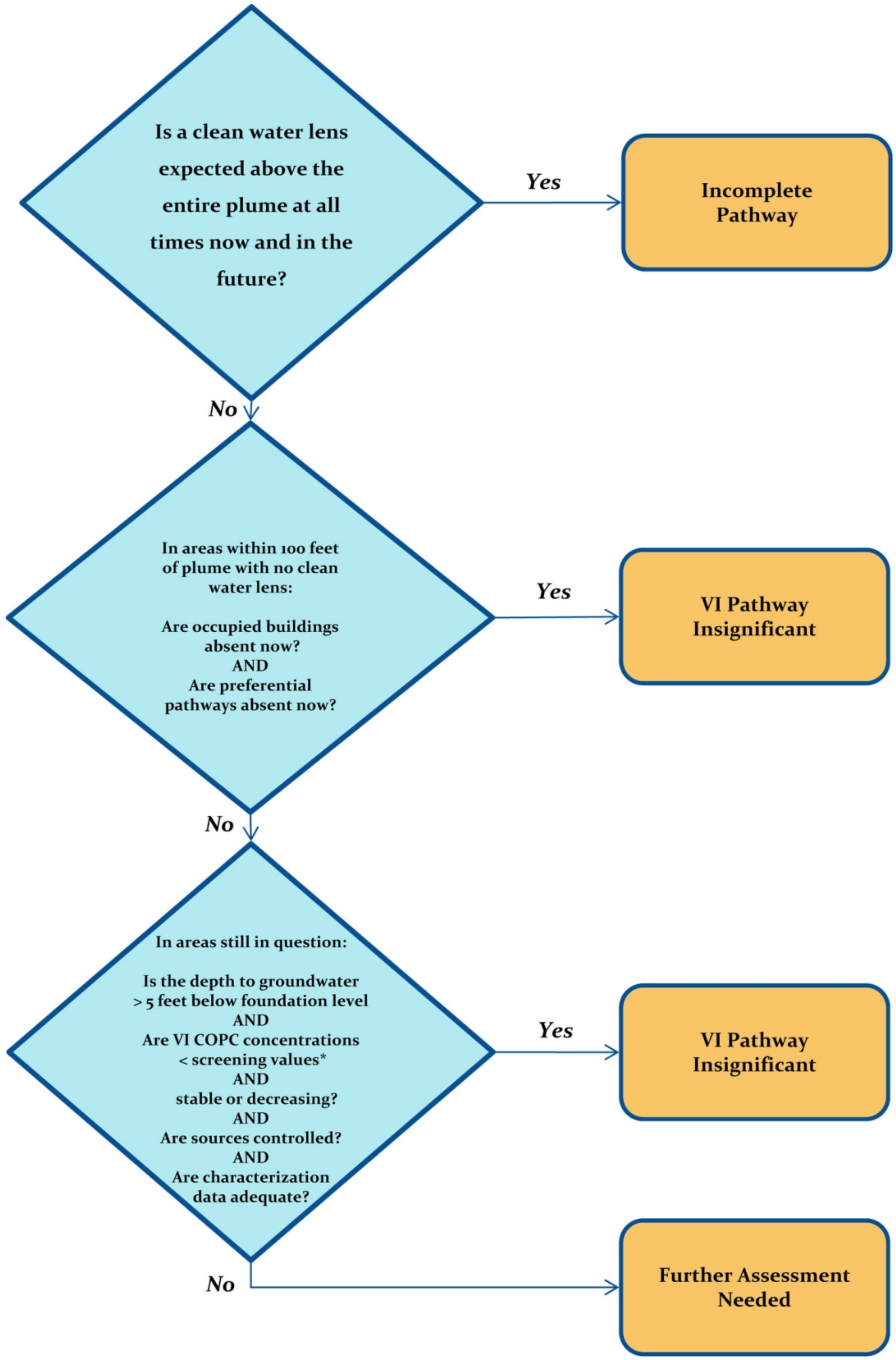

* The VOC, RDX, and EPH/VPH data for the compounds listed in Table 4-1 that are available in MMR Data Warehouse will be reviewed and compared with the screening values in Table 4-1.

VI COPC = Vapor Intrusion Contaminant of Potential Concern

FIGURE 4-1

DECISION DIAGRAM FOR GROUNDWATER PLUME VAPOR INTRUSION EVALUATION

AFCEE - Massachusetts Military Reservation
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

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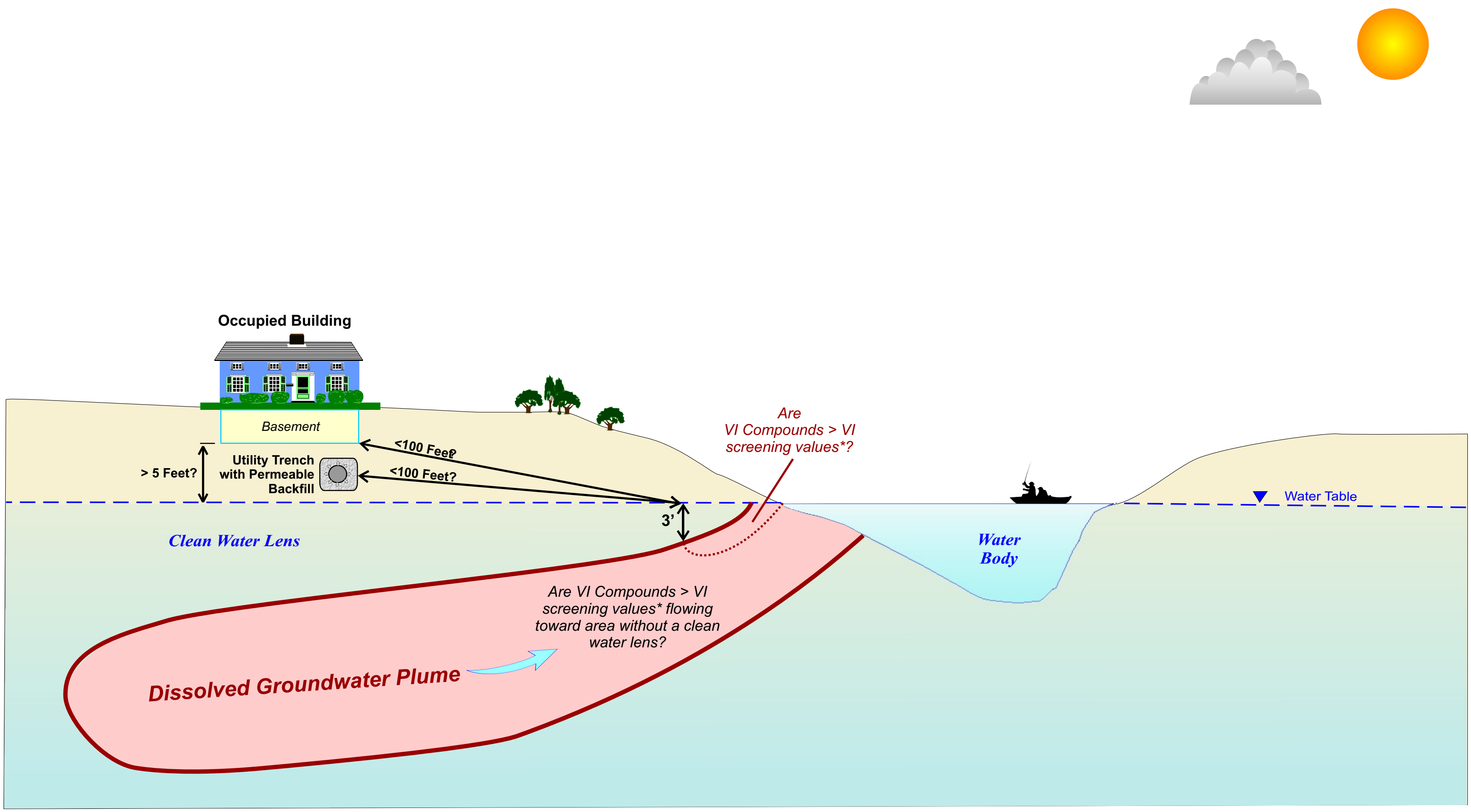

Data Source: AFCEE, November 2009, MMR-AFCEE Data Warehouse

VI = Vapor Intrusion

* The VOC, RDX, and EPH/VPH data for the compounds listed in Table 4-1 that are available in MMR Data Warehouse will be reviewed and compared with the screening values in Table 4-1. Screening values only applicable if depth to groundwater greater than 5 feet below building foundation

FIGURE 4-2

VAPOR INTRUSION CONCEPTUAL SITE MODEL FOR DISSOLVED-PHASE GROUNDWATER PLUME

AFCEE - Massachusetts Military Reservation
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

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Legend

Massachusetts Military Reservation Boundary

*Approximate Area of Soil Contamination

587 Building Number

PFSA Structures Demolished Janurary/February 2011

*"Operations and Maintenance Manual Biosparge/Vapor Recovery System for PFSA". Prepared by Environmental Chemical Corporation for AFCEE/MMR Installation Restoration Program, Massachusetts Military Reservation, Cape Cod, MA, May 2003.

Data Source: AFCEE, MMR-AFCEE Data Warehouse
2007 Aerial Photography from MA ANG
MMR Boundary from Massachusetts Air National Guard 2011

N

0 60 120 Feet

FIGURE 4-3

APPROXIMATE AREA OF SOIL CONTAMINATION AT PFSA

AFCEE - Massachusetts Military Reservation

Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

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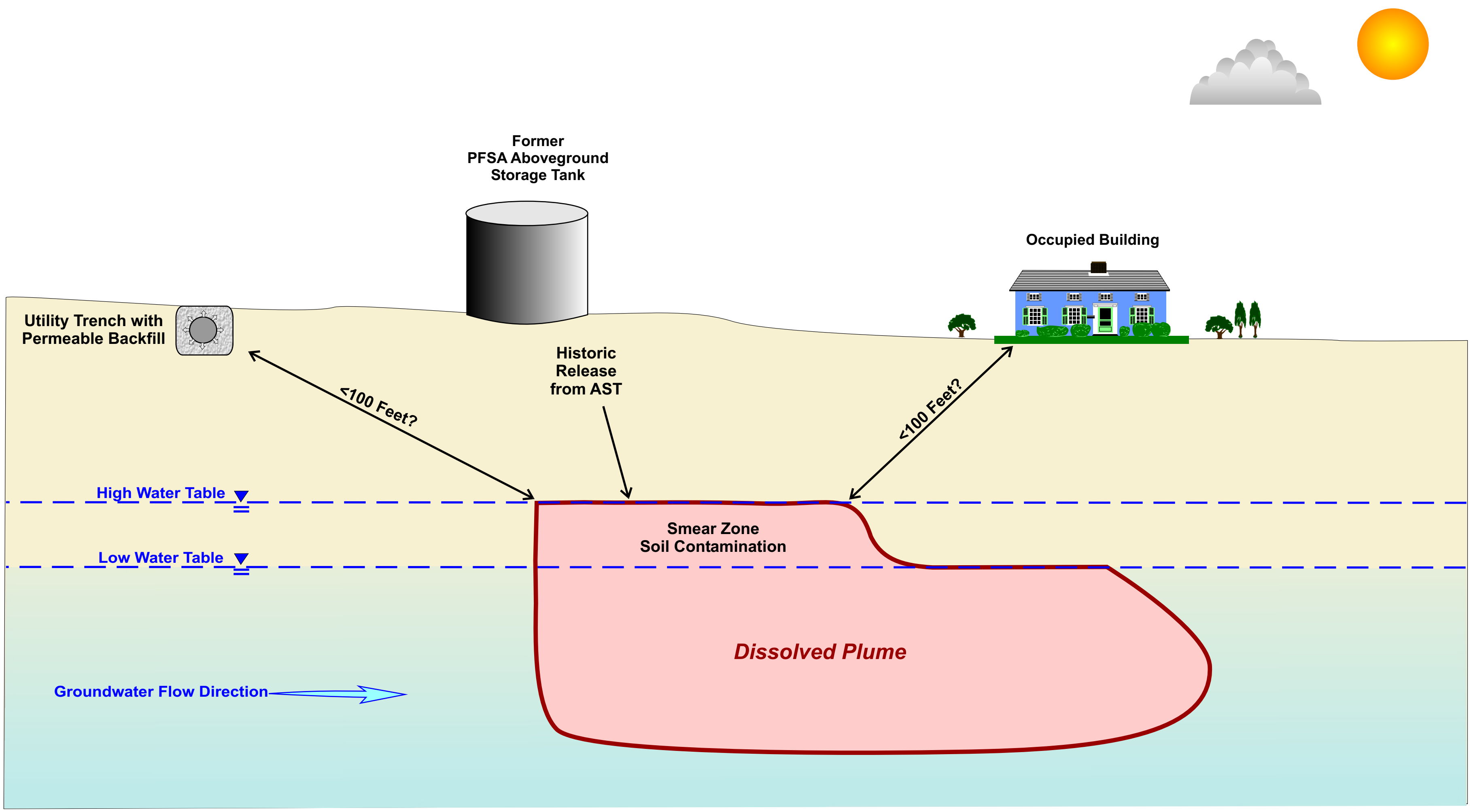

Data Source: AFCEE, November 2009, MMR-AFCEE Data Warehouse

AST = Above Ground Storage Tank

PFSA = Petroleum Fuel Storage Area

FIGURE 4-4

VAPOR INTRUSION CONCEPTUAL SITE MODEL FOR PFSA - SOIL

AFCEE - Massachusetts Military Reservation

Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

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TABLES

Table 1-1
Summary of ROD Submittals for MMR IRP Sites Subject to Vapor Intrusion Evaluation
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Site	Final ROD Date	Date of ROD Signatures		Citation
		USAF	EPA	
Ashumet Valley	March 2009	01 May 2009	10 June 2009	AFCEE 2009c
CS-4*	February 2000	01 February 2000	18 February 2000	AFCEE 2000c
CS-10	August 2009	02 August 2009	19 August 2009	AFCEE 2009b
CS-19	September 2009	25 September 2009	30 September 2009	AFCEE 2009a
CS-20*	February 2000	01 February 2000	18 February 2000	AFCEE 2000c
CS-21*	February 2000	01 February 2000	18 February 2000	AFCEE 2000c
CS-23	September 2007	24 September 2007	28 September 2007	AFCEE 2007b
FS-1	April 2000	04 May 2000	15 May 2000	AFCEE 2000b
FS-12	September 2006	15 September 2006	28 September 2006	AFCEE 2006b
FS-13*	February 2000	01 February 2000	18 February 2000	AFCEE 2000c
FS-28*	October 2000	16 October 2000	23 October 2000	AFCEE 2000a
FS-29*	October 2000	16 October 2000	23 October 2000	AFCEE 2000a
LF-1	September 2007	24 September 2007	28 September 2007	AFCEE 2007a
SD-5	October 2006	14 August 2006	28 September 2006	AFCEE 2006a
PFSA	September 1998	25 September 1998	30 September 1998	AFCEE 1998
FTA-2	September 1998	25 September 1998	30 September 1998	AFCEE 1998

Note:

* - The selected remedies in the RODs for these sites were modified through issuance of the *Final Explanation of Significant Differences for Chemical Spill-4, Chemical Spill-20, Chemical Spill-21, Fuel Spill-13, Fuel Spill-28 and Fuel Spill-29 Groundwater Plumes*. (AFCEE 2008b).

Key:
CS = Chemical Spill
EPA = U.S. Environmental Protection Agency
FS = Fuel Spill
FTA = Fire Training Area
LF = Landfill
PFSA = Petroleum Fuel Storage Area
ROD = Record of Decision
SD = Storm Drain
USAF = U.S. Air Force

Table 1-2
IRP Groundwater Plume Contaminants of Concern
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Groundwater Plumes/Sites	Groundwater Contaminants of Concern
Ashumet Valley	TCE; PCE; manganese; thallium
CS-4	TCE; PCE; 1,1,2,2-TeCA; EDB
CS-10	TCE; PCE
CS-19	RDX
CS-20	PCE
CS-21	TCE
CS-23	TCE; CCl_4
FS-1	EDB (source area: lead; thallium; toluene)
FS-12	EDB; benzene
FS-13	1,2,4-TMB; 1,3,5-TMB
FS-28	EDB
FS-29	EDB; CCl_4
LF-1	PCE; TCE; CCl_4; EDB; 1,1,2,2-TeCA; 1,4-DCB; VC; manganese
SD-5	TCE
FTA-2	NA*
PFSA	NA**

Notes:

* No groundwater contaminants of concern; agreed to contaminants of interest are 1,2,4-TMB, 1,3,5-TMB, and EPH/VPH compounds.

** No groundwater contaminants of concern identified; however, total xylenes and ethylbenzene are soil COCs.

Key:

1,1,2,2-TeCA = 1,1,2,2-tetrachloroethane
1,4-DCB = 1,4-dichlorobenzene
CCl_4 = carbon tetrachloride
COC = contaminant of concern
CS = chemical spill
EDB = ethylene dibromide
FS = fuel spill
FTA = fire training area
LF = landfill
MMR = Massachusetts Military Reservation
NA = not applicable
PFSA = petroleum fuel storage area
PCE = tetrachloroethene
RDX = Royal Demolition Explosive (hexahydro-1,3,5-trinitro-1,3,5-triazine)
SD = storm drain
TCE = trichloroethene
TeCA = tetrachloroethane
TMB = trimethylbenzene
VC = vinyl chloride

Table 1-3
Cleanup Standards for IRP Groundwater Plume Contaminants of Concern
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Analyte	Groundwater Cleanup Standard (µg/L)	Type(1,2)
Benzene	5	MCL
CCl_4	5	MCL
1,4-DCB	5	MMCL
EDB	0.02	MMCL
Lead	15(6)	MCL
Manganese	300	HA(4)
RDX	0.6	EPA risk(5)
PCE	5	MCL
Thallium	2	MCL
TCE	5	MCL
1,1,2,2-TeCA	2	GW-1 (3)
Toluene	1,000	MCL
1,2,4-TMB/1,3,5-TMB	17	RBC (7)
VC	2	MCL

Notes:

1. MCLs and HAs from EPA web page, http://www.epa.gov/safewater/contaminants/index.html.
2. MMCLs from MassDEP web page http://www.mass.gov/dep/water/dwstand.pdf.
3. GW-1 = MassDEP MCP Method 1 Groundwater-1 Standard from MassDEP web page http://www.mass.gov/dep/cleanup/laws/0974_2.htm.
4. HAs from EPA *web page http://www.epa.gov/waterscience/criteria/drinking/dwstandards2009.pdf.*
5. EPA risk = 10^{-6} lifetime cancer risk value.
6. Value reported is the treatment technique action level.
7. 1,2,4-TMB and 1,3,5-TMB risk-based concentrations established as the cleanup level for FS-13 site = 17 µg/L.

Key:

TeCA = tetrachloroethane
DCB = dichlorobenzene
CCl_4 = carbon tetrachloride
EDB = ethylene dibromide
GW-1 = Groundwater-1
HA = Health Advisory
MassDEP = Massachusetts Department of Environmental Protection
MCL = Maximum Contaminant Level
MMCL = Massachusetts MCL
EPA = U.S. Environmental Protection Agency
PCE = tetrachloroethene
RBC = risk-based concentration
RDX = Royal Demolition Explosive
TCE = trichloroethene
TMB = trimethyl benzene
VC = vinyl chloride
µg/L = micrograms per liter

Table 3-1
Summary of Previous MMR Groundwater Plume Vapor Intrusion Assessments
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Documents Reviewed	VI Considered in RA?	VI Conclusion Category[1]	Section VI Was Addressed	Conclusion Summary
AV				
Final Ashumet Valley Groundwater Feasibility Study Appendix A, Final Risk Assessment for Ashumet Valley, June 2007	Yes	Considered and evaluated	3.2.1 - Exposure Pathways; Groundwater	VI evaluated for a residential dwelling using the Johnson & Ettinger model with the following model setup parameters: - maximum detected concentration for each VOC present in groundwater - average depth from ground surface to top of water table - model parameters assume a sandy soil type VI risk above target levels not identified.
			3.4.1 - Ashumet Valley Groundwater	Outside the capture zone, areas south and north of Route 151: - Potential carcinogenic risks and noncarcinogenic hazards from VI are less than the EPA acceptable risk management range (E-04 and E-06) and MassDEP Cumulative Cancer Risk Limit of 1E-05 and an HI of 1.
SWOU (includes FS-28, FS-29, CS-4, CS-20, CS-21, FS-13)				
Final Southwest Operable Unit (SWOU) Remedial Investigation Vol. I - May 1999 *Note that document includes FS-28 and FS-13	Yes	Considered for Area 3 and VI exposure pathway identified as incomplete	6.1 - Draft Public Health Risk Assessment; 6.1.1.3 - Area 3	- The area evaluated (Area 3) consists of the southwest portion of the base and the western portion of the Crane Wildlife Management Area. This portion of the SWOU area has some residential use. The VI pathway was considered incomplete because contaminated groundwater is deep in the aquifer and below the level that would raise concern of contaminant vapors entering buildings. The VI pathway was not considered for any of the other areas included in the SWOU RI
FS-28				
Final FS-28 and FS-29 Groundwater Feasibility Study, January 2000	No	Not considered		
Final Record of Decision for the Fuel Spill-28 and Fuel Spill-29 Plumes - October 2000				
CS-4				
Final Record of Decision for the CS-4, CS-20, CS-21, and FS-13 Plumes - February 2000	No	Not considered		
Final Southwest Operable Unit Feasibility Study - June 1999				
Final Southwest Operable Unit (SWOU) Remedial Investigation Vol. I - May 1999				
CS-20				
Final Record of Decision for the CS-4, CS-20, CS-21, and FS-13 Plumes - February 2000	No	Not considered		
Final Southwest Operable Unit Feasibility Study - June 1999				
Final Southwest Operable Unit (SWOU) Remedial Investigation Vol. I - May 1999				
CS-21				
Final Record of Decision for the CS-4, CS-20, CS-21, and FS-13 Plumes - February 2000	No	Not considered		
Final Southwest Operable Unit Feasibility Study - June 1999				
Final Southwest Operable Unit (SWOU) Remedial Investigation Vol. I - May 1999				
FS-29				
Final FS-28 and FS-29 Groundwater Feasibility Study, January 2000	No	Not considered		
Final Record of Decision for the Fuel Spill-28 and Fuel Spill-29 Plumes - October 2000				
Final Southwest Operable Unit Feasibility Study - June 1999				
Final Southwest Operable Unit (SWOU) Remedial Investigation Vol. I - May 1999				
FS-13				
Final Record of Decision for the CS-4, CS-20, CS-21, and FS-13 Plumes - February 2000	No	Not considered		

Table 3-1
Summary of Previous MMR Groundwater Plume Vapor Intrusion Assessments
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Documents Reviewed	VI Considered in RA?	VI Conclusion Category[1]	Section VI Was Addressed	Conclusion Summary
FS-1				
Remedial Investigation Report, Area of Contamination, FS-1 Final, May 1999	No	Not considered		
Final Feasibility Study, Area of Contamination, FS-1 Final - May 1999				
Record of Decision, Area of Contamination FS-1 Final - April 2000				
FS-12				
Final Fuel-Spill 12 Groundwater Feasibility Study - September 2005	Yes	Considered and VI exposure pathway identified as incomplete	Appendix A - Risk Assessment for the FS-12 Plume; Section 3.2.1 - Exposure Pathways	Not evaluated because the depth to groundwater is over 100 ft bgs, on average.
FTA-2				
Record of Decision for Areas of Contamination FTA-2/ LF-2, PFSA/FS-10/FS-11, SD-2/FS-6/FS-8, SD-3/FTA-3/CY-4, and SD-5/FS-5 Source Areas.	No	Not considered		
PFSA				
Record of Decision for Areas of Contamination FTA-2/ LF-2, PFSA/FS-10/FS-11, SD-2/FS-6/FS-8, SD-3/FTA-3/CY-4, and SD-5/FS-5 Source Areas.	No	Not considered		
LF-1				
Final Landfill-1 Source Area and Groundwater Feasibility Study - May 2006	Yes	Considered and VI exposure pathway identified as incomplete	Appendix A Risk Assessment for the LF-1 Plume; Section 3.0 Human Health Risk Assessment; 3.4.3 Uncertainty Analysis	- VI pathway was not further evaluated because groundwater contamination is 100 ft or more bgs. - Exception is where PCE and TCE have been detected in shallow groundwater beneath the harbors at < 1 µg/L.
Final Record of Decision for Landfill-1 Source Area and Groundwater - September 2007			2.7 - Summary of Site Risks	Inhalation of vapors was not evaluated in the risk assessment because: - Post-Closure Monitoring results concluded that total VOC readings are zero and the regulatory limit for landfill gas (25 percent of the lower explosive limit at the assigned boundary) is not currently being exceeded at LF-1. - The regulatory limit is unlikely to be exceeded in the future. This conclusion is based on the relatively high porosity of the soil and the great horizontal distance the landfill gas would have to travel to reach the base boundary.
CS-23				
Final Chemical Spill-23 Remedial Investigation - March 2005	Yes	Considered and VI exposure pathway identified as incomplete	6.2 - Exposure Assessment; 6.2.1 - Exposure Pathways	Not evaluated further because concentrations of VOCs greater than Maximum Contaminant Levels were not detected at depths less than 100 ft.
Final Chemical Spill-23 Plume Feasibility Study - January 2006				
Final Record of Decision for Chemical Spill-23 Groundwater - September 2007				
CS-19				
Final Chemical Spill-19 Remedial Investigation Report, Volume I of II - October 2003	No	Not considered		
Final Chemical Spill-19 Groundwater Feasibility Study - April 2009				
Final Chemical Spill-19 Record of Decision - September 2009				
CS-10				
Final Chemical Spill-10 Remedial Investigation Report, Volume I of IV, Text, Figures and Tables - September 2001	No	Not considered		
Final Chemical Spill-10 Groundwater Feasibility Study - August 2003				
Final Record of Decision for Chemical Spill-10 Groundwater - August 2009				

Table 3-1
Summary of Previous MMR Groundwater Plume Vapor Intrusion Assessments
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Documents Reviewed	VI Considered in RA?	VI Conclusion Category[1]	Section VI Was Addressed	Conclusion Summary
SD-5				
Final Storm Drain-5 Groundwater Feasibility Study - September 2004	No	Not considered		
Final Record of Decision for Groundwater at Eastern Briarwood, Western Aquafarm, and Storm Drain-5 - September 2006				
Final Risk Assessment for Eastern Briarwood and Western Aquafarm - July 2005				

Note:

[1] The VI Conclusion Category is characterized by either:
Considered and Evaluated - The VI exposure pathway was discussed and evaluated either quantitatively or qualitatively.
Considered and VI Exposure Pathway Identified as Incomplete - The VI exposure pathway was discussed, but it was concluded that a complete pathway was not present.
Not Considered - VI was not considered or mentioned in the risk assessment.

Key:
AOC = area of concern
AV = Ashumet Valley Plume
bgs = below ground surface
CS = Chemical Spill
EPA = U.S. Environmental Protection Agency
FS = Fuel Spill
ft = feet
FTA = Fire Training Area
HI = hazard index
LF = Landfill
MassDEP = Massachusetts Department of Environmental Protection
PCE = tetrachloroethene
PCM = post-closure monitoring
PFSA = petroleum fuel storage area
RA = risk assessment
SD = Storm Drain
SWOU = Southwest Operable Unit
TCE - trichloroethene
VI = vapor intrusion
VOC = volatile organic compound
µg/L = micrograms per liter

Table 4-1
Screening Values for Groundwater to Indoor Air
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

VI Compound of Potential Concern (COPC)	Massachusetts Contingency Plan Method 1 GW-2 Standard (µg/L) [1]	Generic Unrestricted Groundwater Screening Level (µg/L) [2]
Benzene	2,000	5 †
Carbon Tetrachloride	2	5 †
Chlorobenzene	200	100 †
Chloroethane	NE	3,400
1,2-Dichlorobenzene	2,000	720
1,4-Dichlorobenzene	200	75 †
1,1-Dichloroethane	1,000	12
1,2-Dichloroethane	5	5 †
1,1-Dichloroethene	80	33
cis-1,2-Dichloroethene	100	70 †
trans-1,2-Dichloroethene	90	100 †
1,2-Dichloropropane	3	5 †
Ethylbenzene	20,000	700 †
Ethylene Dibromide (1,2-Dibromoethane)	2	0.38
Methylene Chloride (Dichloromethane)****	10,000	840
Royal Demolition Explosive (RDX)	50,000	NE
1,1,2,2-Tetrachloroethane	9	6.8
Tetrachloroethene	50	13
Toluene	50,000	4,100
1,1,1-Trichloroethane	4,000	1,400
1,1,2-Trichloroethane	900	5 †
Trichloroethene	30	5 †
1,2,4-Trimethylbenzene	NE	7.8
1,3,5-Trimethylbenzene	NE	7.8**
Vinyl Chloride	2	2 †
Xylenes	9,000	10,000 †
C5 through C8 Aliphatic Hydrocarbons*	3,000	NE
C9 through C12 Aliphatic Hydrocarbons*	5,000	NE
C9 through C18 Aliphatic Hydrocarbons*	5,000	NE
C9 through C10 Aromatic Hydrocarbons*	7,000	NE
C11 through C22 Aromatic Hydrocarbons*	50,000	NE
2-Methylnaphthalene	2,000	12 ***
Naphthalene	1,000	12

Notes:

NE = none established

1. 310 CMR 40.0974(2) http://www.mass.gov/dep/cleanup/laws/0974_2.htm. Note that for the purposes of this MMR VI evaluation, GW-2 standards are only applicable where the depth to groundwater is at least 5 feet below foundation level. This is consistent with the derivation method for GW-2 standards (310CMR40.0983(3)) and is also consistent with the way the EPA Generic Unrestricted Groundwater Screening Levels (see Note 2) are applied." GW-2 values were last updated on 03 April 2012.
2. EPA, 2002, Draft Guidance for Evaluating the VI to Indoor Air Pathway from Groundwater and Soils http://www.epa.gov/osw/hazard/correctiveaction/eis/vapor/complete.pdf, using target risk levels of $1x10^{-6}$ excess lifetime cancer risk and noncancer hazard quotient of 0.1 in accordance with best practices for vapor intrusion screening to account for cumulative effects from multiple chemicals. Note that groundwater screening values are applicable where the depth to groundwater is at least 5 feet below foundation level. Values updated using May 2012 Regional Screening Levels (Residential Indoor Air) for Chemical Contaminants at Superfund Sites http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm.

† When the Generic Screening Level is less than the U.S. Safe Drinking Water Act Maximum Contaminant Level (http://www.epa.gov/safewater/contaminants/index.html#mcls), the Screening Level defaults to the MCL.

* Hydrocardon ranges reported under MassDEP Extractable Petroleum Hydrocarbon (EPH) and Volatile Petroleum Hydrocarbon (VPH) analytical methods.

** Value for 1,2,4-Trimethylbenzene is used as a surrogate.
*** Value for naphthalene is used as a surrogate.
**** Methylene chloride is a common laboratory contaminant and may not be site related.

Table 5-1
MMR Vapor Intrusion Evaluation Summary
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Plume ID	Entire Plume	100 Feet Around Plume Area without Clean Water Lens	Plume Area Without Clean Water Lens and Within 100 Feet of Buildings or Preferential Airflow Pathways				Conclusion
	Clean Water Lens Present?	Occupied Buildings or Preferential Airflow Pathways Absent?	Are VI Compound Concentrations < Screening Values (if applicable*)?	Are VI Compound Concentrations Stable or Decreasing?	Are Sources Controlled?	Are Characterization Data Adequate?	Are VI Risks Unlikely to Exceed Target Levels?
AV	No	No	Yes	Yes	Yes	Yes	Yes
CS-4	Yes	NA	NA	NA	NA	NA	Yes
CS-10	No	No	Yes	Yes	Yes	Yes	Yes
CS-19	No	Yes	NA	NA	NA	NA	Yes
CS-20	Yes	NA	NA	NA	NA	NA	Yes
CS-21	Yes	NA	NA	NA	NA	NA	Yes
CS-23	Yes	NA	NA	NA	NA	NA	Yes
FS-1	No	Yes	NA	NA	NA	NA	Yes
FS-12	No	Yes	NA	NA	NA	NA	Yes
FS-13	No	No	Yes	Yes	Yes	Yes	Yes
FS-28	No	No	Yes	Yes	Yes	Yes	Yes
FS-29	Yes	NA	NA	NA	NA	NA	Yes
LF-1	Yes	NA	NA	NA	NA	NA	Yes
SD-5	No	No	Yes	Yes	Yes	Yes	Yes
PFSA	No	No	No	Yes	Yes	Yes	Unknown
FTA-2	No	No	No	Yes	Yes	Yes	Yes

Note: *VI screening values only applicable if depth to groundwater greater than 5 feet below grade.

Key:
AV = Ashumet Valley
CS = Chemical Spill
FS = Fuel Spill
FTA = Fire Training Area
LF = Landfill
PFSA = Petroleum Fuel Storage Area
NA = not analyzed
SD = Storm Drain

APPENDIX A

Ashumet Valley Plume Vapor Intrusion Evaluation

TABLE OF CONTENTS

Figures

TABLE OF CONTENTS

Tables

ACRONYMS AND ABBREVIATIONS

AFCEE	Air Force Center for Engineering and the Environment
AV	Ashumet Valley
bgs	below ground surface
BRL	below the reporting limit
COC	contaminant of concern
COPC	contaminant of potential concern
CS	chemical spill
CSM	conceptual site model
ft	foot/feet
FTA-1	Fire Training Area-1
gpm	gallons per minute
MCL	Maximum Contaminant Level
MMR	Massachusetts Military Reservation
msl	mean sea level
PCE	tetrachloroethene
RI	Remedial Investigation
ROD	Record of Decision
SPEIM	System Performance and Ecological Impact Monitoring
STP	sewage treatment plant
TCE	trichloroethene
VI	vapor intrusion
VOC	volatile organic compound
µg/L	micrograms per liter

A1.0 ASHUMET VALLEY PLUME VAPOR INTRUSION DATA EVALUATION

A1.1 ASHUMET VALLEY PLUME CONCEPTUAL SITE MODEL

The Ashumet Valley (AV) groundwater plume is a dilute dissolved-phase groundwater plume located in the Town of Falmouth just south of the Massachusetts Military Reservation (MMR) (Figure 1-2 of main document). The sources of the AV groundwater plume (Figure A-1) are the former Fire Training Area-1 (FTA-1) and the former MMR Sewage Treatment Plant (STP) referred to as Chemical Spill-16 (CS-16) and CS-17.

The primary groundwater contaminants of concern (COCs) for the AV plume are the volatile organic compounds (VOC) tetrachloroethene (PCE) and trichloroethene (TCE). The AV plume boundary is currently defined as the extent of groundwater containing PCE or TCE at concentrations exceeding the Maximum Contaminant Level (MCL) of 5 micrograms per liter (μg/L) for each compound. Manganese and thallium are also COCs at AV; however, these compounds are not volatile and thus are not a vapor intrusion (VI) concern. The AV plume has been divided into three distinct areas referred to as the northern plume zone, the central plume zone, and the southern plume zone (Figure A-2). Due to the effectiveness of the remedial actions and through natural attenuation mechanisms, the plume in the northern and central zones has become fragmented and is characterized by isolated discontinuous zones of PCE or TCE contamination at concentrations above the MCL. PCE was the prevalent COC in the northern plume zone between the source areas and Ashumet Pond; however, the plume is no longer delineated in this area since groundwater COC concentrations are now below the MCL (but PCE is still detected in some isolated areas). TCE is rarely detected in this area between the source areas and Ashumet Pond. The portion of the plume delineated near the boundary of the northern and central plume zones consists primarily of TCE contamination and PCE is the dominant COC in the plume lobe located between 95EW0702 and 95EW0703 (i.e., the southern portion of the central plume zone). The plume that remains in the southern plume zone consists of both PCE and TCE; however, PCE is the dominant COC and where TCE is present it is coincident with the PCE, but at lower concentrations. The plume in the southern plume zone is also becoming fragmented into discontinuous zones of PCE and/or TCE at concentrations above the MCL

(although the plume boundary in the southern zone shown on Figures A-1 and A-2 shows a contiguous plume).

The AV source areas are located in the southeastern corner of the MMR (Figure A-1). At FTA-1, firefighter training exercises were held from 1958 to 1985, during which time flammable waste liquids (including jet fuel, diesel fuels, waste oils, solvents, paint thinners, transformer oils, and spent hydraulic fluids) were burned and extinguished. The former MMR STP, which operated from 1936 to 1995, released treated wastewater to a series of sand infiltration beds (CS-16). De-watered sewage sludge was also disposed of in a nearby wooded area (CS-17) (AFCEE 2010). A Remedial Investigation (RI) report concluded that the MMR STP was not an ongoing source of VOC contamination to groundwater, but soil contamination at FTA-1 remained a potential source of VOCs to groundwater (ABB 1995). Between June 1995 and September 1997, The Air Force Center for Engineering and the Environment (AFCEE) conducted soil excavation and on-site thermal treatment of contaminated soils at FTA-1 in order to achieve closure of this source area (AFCEE 2000). The CS-16/CS-17 source area was remediated through excavation and off-site disposal of soils (AFCEE 2003).

Based on the most recent depiction of the AV plume boundary, the predominantly TCE plume lobe to the north (currently straddling the northern plume zone and the central plume zone) is approximately 3,300 feet (ft) long, the PCE-dominated lobe between 95EW0702 and 95EW0703 is approximately 3,100 ft long, and the southernmost portion is approximately 9,500 ft long. A plan view of the AV plume along with the location of cross-section lines and the monitoring locations used to support this VI evaluation are shown in Figure A-2. A north to south cross-sectional view of the AV plume is provided as Figure A-3 showing the extent of PCE contamination; and as Figure A-4 showing the extent of TCE contamination. Figure A-5 is a line of cross-section from north to south down the western edge of the southern plume zone near the Backus River showing the extent of PCE contamination. Figure A-6 is a west to east cross-sectional view of the extent of PCE in the southern plume zone. The AV plume has a maximum width of approximately 2,150 ft (in the southern plume zone) and a maximum thickness of approximately 65 ft (in the central plume zone). Characteristic of many of the MMR groundwater plumes, the AV plume descended in the aquifer as it migrated from its source area

due to recharge accretion which has resulted in the majority of the plume (now located to the south of Ashumet Pond) being located relatively deep in the aquifer and overlain by a lens of clean groundwater. However, in the area near the Backus River, a portion of the plume upwells and discharges to surface water.

The upper boundary of the northern TCE-dominated plume lobe is approximately 115 ft below ground surface (bgs) and approximately 70 ft below the water table. The upper boundary of the PCE-dominated lobe north of 95EW0703 is approximately 125 ft bgs and 90 ft below the water table. The upper boundary of the plume in the southern plume zone in the upland region to the east of the Backus River (shown on Figures A-3 and A-4) is greater than 80 ft bgs and greater than 50 ft below the water table. Closer to the Backus River (Figure A-5), the upper boundary of the plume is typically greater than 60 ft bgs and 50 ft below the water table along the flanks of the river. However, directly below the river channel, data indicate that the plume rises in the aquifer as the groundwater upwells to discharge to the river system. This convergence of flow to the river results in sub-MCL detections of PCE and TCE in Backus River surface water (AFCEE 2010).

The topography of the land above the AV plume can be characterized as a broad, flat, and gently sloping glacial outwash plain (AFCEE 2010). Within the footprint of the plume, the maximum and minimum ground surface elevations are 84 ft mean sea level (msl), and 10 ft msl, respectively.

The groundwater flow direction in the vicinity of the AV plume is generally to the south. Flow within the aquifer is primarily horizontal with stronger vertical gradients near surface water bodies such as rivers and ponds that increase the potential for vertical flow. The depth to water in the vicinity of the AV plume ranges from less than a few feet near the Backus River and cranberry bogs to approximately 45 ft bgs in the upland areas in the central plume zone; the elevation of the water table within the AV plume footprint area ranges from approximately 35 ft msl in the north to 10 ft msl in the south. The aquifer saturated thickness in the AV plume area is up to 275 ft.

The original remedial design for the AV plume consisted of three extraction wells along the axis of the plume in the central plume zone, two treatment plants, and two infiltration trenches, installed in 1999 under an Interim Record of Decision (ROD) (ANG 1995). The remedial system began operation on 22 November 1999 and was designed to extract and treat 1,200 gallons per minute (gpm) of groundwater from the aquifer. On 18 May 2007, the treatment system was optimized by the shutdown of the two northernmost extraction wells, since these wells had substantially completed remediation of the aquifer within their capture zones. The original remedial system is currently operating using one extraction well (95EW0703) processing 350 gpm through one of two treatment plants. In 2009, a final ROD (AFCEE 2009) was completed and the AV remedial system was expanded to add treatment for a portion of the AV plume in the southern zone. The expansion involved adding a new extraction well (95EW0704), a mobile treatment unit, and a bubbler in the Backus River for discharge of the treated water. The new leading edge system began operation on 24 August 2009 at a design flow rate of 175 gpm. The total volume of contaminated groundwater extracted and treated at AV is currently 525 gpm (AFCEE 2010). The ongoing remedial actions at the AV plume are managed under the System Performance and Ecological Impact Monitoring (SPEIM) program.

The remedial objective of the selected alternative in the Final ROD was for plume capture through the operation of the original optimized remedial system; and to remove contaminant mass in the southern portion of the plume though operation of the new leading edge system. Based on the modeling presented in the Final ROD (AFCEE 2009) using the 2008 AV plume shells and assuming continued operation of 95EW0703 at 350 gpm and 95EW0704 at 175 gpm, transport model simulations predict that each of the remedial systems could be shut down by approximately 2018, with PCE and/or TCE concentrations reaching MCLs by 2019 in the central plume zone and by 2021 in the southern plume zone.

A1.2 STEP 1: CLEAN WATER LENS

As established in Section 4.1.1 and depicted graphically in Figure 4-1 of the main document, the first step in evaluating the possibility of VI for a groundwater plume is determining whether a continuous 3-ft-thick clean water lens is present above the entire plume and is expected to remain for the foreseeable future as long as the plume exists. If the evaluation indicates that a clean water lens is present using the criteria presented in Section 4.1.1 of the main document, it can be concluded that the VI pathway is incomplete and no further evaluation is required.

The clean water lens evaluation included a review of the analytical data for the two volatile AV COCs (PCE and TCE), as well as other plume-related VOCs included in the list of VI contaminants of potential concern (COPCs) in Table 4-1 of the main document. For this AV plume evaluation, the absence of plume-related VOC detections in groundwater in the portion of the aquifer above the plume footprint will define the presence of clean water. In addition, residual sub-MCL PCE groundwater contamination that remains between the former source area and Ashumet Pond is evaluated since it was historically relatively shallow in the aquifer as it migrated from the sources to upwell and discharge to Ashumet Pond.

The locations of all the monitoring points used for this VI evaluation are shown on Figure A-2. The most recent PCE and/or TCE data used to support this evaluation are shown on cross-sectional views of the AV plume (Figures A-3 through A-6). All the analytical data used to support the VI evaluation are summarized in Table A-1. The well construction and sampling location information are included in Table A-2.

The following subsections evaluate the clean water lens at the four AV plume areas of concern: the shallow groundwater near the source areas, which is located on-base; the shallow groundwater in the area where the plume historically upwelled to discharge to the western shore of Ashumet Pond; the detached AV plume located off base to the north and east of the Backus River (i.e., the upland area); and where the plume rises to discharge to the Backus River.

A1.2.1 AV Plume Source Area

Due to the effectiveness of remedial activities in the source area as discussed in Section A1.1, monitoring data do not indicate these areas are acting as continuing sources of contamination to groundwater (AFCEE 2010). Long-term monitoring data, including data collected as recently as 2011 from wells immediately downgradient of the FTA-1 source area indicate that detectable concentrations of plume-related VOCs (PCE) remain in groundwater at or near the water table (Figures A-2 and A-3, and Table A-1). With the exception of one location (30MW0431), these PCE detections are at concentrations below the MCL and therefore the AV plume has not been delineated in this area since 2007. Based on a review of these data, it can be concluded that a clean water lens does not exist in this area downgradient of the AV FTA-1 source area and a complete VI pathway cannot be ruled out. Further VI evaluation (i.e., Step 2 of the VI evaluation process) is warranted for the AV source area.

A1.2.2 Western Shore of Ashumet Pond

Although the AV plume has not been delineated between the AV source areas and Ashumet Pond since 2007, residual sub-MCL detections of PCE and TCE have been reported in monitoring wells in this area. Long-term monitoring data, including data collected as recently as 2012, from wells in this area indicate that detectable concentrations of plume-related VOC compounds (PCE) remain in two monitoring wells (USFW347020 and USFW388037) screened at or near the water table (Figure A-2 and Table A-1). Therefore, a clean water lens cannot be demonstrated throughout this area and a complete VI pathway may be present. Further VI evaluation (i.e., Step 2 of the VI evaluation process) is warranted for the area near the western shore of Ashumet Pond.

A1.2.3 AV Plume South of Ashumet Pond Upland from Backus River

As described in the conceptual site model (CSM) in Section A1.1, the most recent monitoring data indicate that the AV groundwater plume is located relatively deep in the aquifer, except near the Backus River where the plume upwells to discharge. Characterization data collected under the SPEIM program confirm that the AV plume is overlain by a substantial thickness of clean

water well in excess of 3 ft in the upland areas away from the Backus River. The data that support this aspect of the CSM (Figures A-3 and A-4, and Table A-1) are as follows:

- Groundwater vertical profile data collected along the axis of the plume between 2003 and 2012 at 95DP0234, 95DP0214, 95MW1233A, 95DP0218, 95DP0221, 95DP0224, and 95DP0223 provide evidence of a clean water lens that is at least 40 ft thick.
- Groundwater vertical profile data collected in 1998 at 95MW0211A provide evidence of a clean water lens that was at least 50 ft thick at that time. It is noted that this location is now outside of the plume boundary, but does still provide useful data to illustrate the extent and thickness of the clean water lens above the AV plume.

In summary, characterization and monitoring data from multiple locations throughout the portion of the Ashumet Valley plume south of Ashumet Pond and not near the Backus River area confirm the presence of a clean water lens overlying the entire plume well in excess of the 3-ft thickness criterion used for this VI screening evaluation. It is acknowledged, however, that some of these characterization data are not recent (i.e., dating back to 1998 in some cases). But when combined with more recent data collected through 2012 and the overall understanding of the hydrogeologic aspect of the CSM, they still provide sound lines of evidence that this portion of the plume is located relatively deep in the aquifer and is overlain by a substantial thickness of clean water. Therefore, no further VI evaluation is required for this area.

A1.2.4 AV Plume in Vicinity of Backus River

The western edge of the AV plume rises in the aquifer as it approaches the Backus River (Figures A-2 and A-5). Based on detailed vertical profile characterization data collected in 2004 by the U.S. Geological Survey (AFCEE 2006), the zone of upwelling is limited to the area immediately below the river channel. Slightly to the west and east of the river channel, data indicate that the AV plume is overlain by a clean water lens in excess of 60 ft thick (Figures A-2, A-5, and A-6). However, vertical profile data collected during the 2004 investigation at USFW653A01 confirmed that the plume, characterized by detections of both PCE and TCE (Table A-1), did rise steeply in the aquifer to discharge to the river channel at that time. This aspect of the CSM is further supported based on consistent detections of PCE and TCE in surface water collected from the Backus River over recent years, suggesting ongoing plume discharge (AFCEE 2010). Therefore, although the presence of a clean water lens in excess of 3 ft above

the plume adjacent to the river can be confirmed, data indicate that a clean water lens is not present at all times in the area immediately below the Backus River channel, and a complete VI pathway cannot be ruled out. Further VI evaluation (i.e., Step 2 of the VI evaluation process) is warranted for the AV plume in the vicinity of the Backus River.

A1.3 STEP 2: BUILDINGS AND PREFERENTIAL AIRFLOW PATHWAYS

If it is determined that a constant 3-ft-thick lens of clean water does not exist or its presence cannot be demonstrated with an adequate level of certainty, the next step in a VI assessment is the evaluation of the proximity of potential receptors (Section 4.1.2 of main document). This is necessary for the source area groundwater, groundwater in the vicinity of the western shore of Ashumet Pond, and groundwater along the western edge of the AV Plume in the vicinity of the Backus River.

A1.3.1 AV Plume Source Area

The extent of plume-related VOC detections in monitoring wells screened at or near the water table in the AV plume source area is shown on Figure A-7; note that the 2007 AV plume boundary has been added to Figure A-7 for reference. As illustrated on this figure, the VI COPC detections at the water table are limited to wells that are located on base and immediately south of the FTA-1 source area. The land above this area is largely undeveloped, but there are buildings located near several of the monitoring wells where residual detections of plume-related VI COPCs remain (Figure A-7 and Table A-1). Specifically, the MMR sewage treatment facility building and buildings associated with the Massachusetts Alternative Septic System Test Center are present as close as approximately 200 ft from the monitoring wells along Kittredge Road (30MW0426B, 30MW0430 and 30MW0431) where PCE has been detected at or near the water table. Based on the available data density in this area, it is assumed that the extent of PCE in groundwater may extend to within the 100 ft distance criterion presented in Section 4.1.2 of the main document. Furthermore, underground utilities exist in this area (e.g., beneath Kittredge Road) that could potentially act as preferential airflow pathways to these and/or more distant buildings. Therefore, the proximity of these buildings and underground utilities to the PCE detections prompts further VI evaluation (i.e., Step 3 of the VI evaluation process) in this area.

A.1.3.2 Western Shore of Ashumet Pond

The extent of plume-related VI COPC detections in monitoring wells screened at or near the water table along the western shore of Ashumet Pond is shown on Figure A-8. Similar to Figure A-7, the 2007 AV plume boundary is shown for reference. As illustrated on this figure, the detections (PCE, as shown in Table A-1) are limited to two wells that are located off-base. The land above this area is largely undeveloped, but there are buildings located relatively near one of the monitoring wells where residual detections of PCE remain (Figure A-8). Specifically, a residence property on Sandwich Road containing several buildings is located approximately 210 ft from USFW388037. Although this residence is located cross gradient from USFW388037, underground utilities are present below Sandwich Road that service this building so it has been assumed that this building is within the 100 ft distance criterion presented in Section 4.1.2 of the main document, which prompts further VI evaluation (i.e., Step 3 of the VI evaluation process).

A.1.3.3 AV Plume in Vicinity of Backus River

As noted in Section A.1.2.4, along the western edge of the AV plume near the Backus River, plume-related VI COPCs have been detected at or near the water table immediately below the river channel (Figures A-5 and A-6). The land above this area is used for cranberry farming operations and there are currently no buildings located within 100 ft of the sampling locations where detections of plume-related compounds were identified. However, it is possible that buildings may be constructed within 100 ft of where these water-table detections were located at some point in the future. This area is off base and thus is not controlled by base entities. Therefore, the proximity of the potential future buildings prompts further VI evaluation (i.e., Step 3 of the VI evaluation process) in the area along the western edge of the AV plume in the vicinity of the Backus River.

A1.4 STEP 3: COMPARE GROUNDWATER CONCENTRATIONS TO VI SCREENING VALUES

If a constant 3-ft-thick clean water lens cannot be identified with reasonable certainty or is not present, and an occupied building or preferential airflow pathway is or could be located within

100 ft of detections of any VI COPC, the third step in the VI assessment is the comparison of groundwater concentrations to the groundwater-to-indoor-air screening values presented in Table 4-1 of the main document. Section 4.1.3 of main text outlines this step in detail.

For the AV plume, plume-related VOC concentrations detected at or near the water table in three areas (source area, near the western shore of Ashumet Pond, and in the vicinity of the Backus River) were compared to their respective screening values. Note that a screening value comparison is only applicable when the depth to groundwater at the building being assessed is greater than 5 ft below building foundation level; this is the case for the AV source area, near the western shore of Ashumet Pond, and is assumed for any future structures near the Backus River.

A1.4.1 AV Plume Source Area

Locations that provide plume-related VOC groundwater data at or near the water table in the source area are shown on Figure A-7. Table A-3 provides a summary of the most recent PCE detections from these locations compared to the screening values.

PCE detections at water table monitoring wells 30MW0417C, 30MW0426B, 30MW0427, 30MW0430, and 30MW0431 range from below the reporting limit (BRL) of 1 µg/L to 5.7 µg/L. As shown in Table A-3, these PCE detections are well below both VI screening values. Since this area has no ongoing source and concentrations are expected to continue to decline through natural attenuation processes, higher PCE concentrations than those currently detected are not anticipated in the future. Since PCE concentrations are below the relevant VI screening values, the VI exposure pathway is considered insignificant in this area.

A.1.4.2 Western Shore of Ashumet Pond

Locations that provide plume-related VOC groundwater data at or near the water table in the area near the western shore of Ashumet Pond are shown on Figure A-8. Table A-3 provides a summary of the most recent PCE detections from these locations compared to the screening values.

PCE concentrations at water table monitoring wells USFW347020 and USFW388037 were at BRL concentrations (i.e., less than 1 µg/L) when last sampled in 1998 and 2012, respectively. As shown in Table A-3, these PCE detections are well below both VI screening values. Similar to the groundwater near the source area, this area has no ongoing source and concentrations are expected to continue to decline through natural attenuation processes. Therefore, the VI exposure pathway is considered insignificant in this area.

A.1.4.3 AV Plume in Vicinity of Backus River

Locations that provide plume-related VOC groundwater data at or near the water table along the western edge of the AV plume in the vicinity of the Backus River are shown on Figures A-5 and A-6. Table A-3 provides a summary of the most recent PCE and TCE detections from these locations compared to the screening values.

PCE detections in the shallowest sampled intervals at direct push vertical profile borings USFW653A01 and USFW657A01 were 3.0 µg/L and 0.03 µg/L, respectively. As shown in Table A-3, these PCE detections are well below both VI screening values established for PCE. In addition, the TCE detection of 2.2 µg/L reported at USFW653A01 is below both of the VI screening values established for TCE (Table A-3). Since this area has no nearby receptors, the VI exposure pathway is currently incomplete. The potential exists that buildings could be constructed within 100 ft of these detections in the future, but the concentrations detected are well below the relevant VI screening values, and therefore the VI exposure pathway would be insignificant if a complete exposure pathway was present. Furthermore, there is no ongoing source and concentrations are expected to decline in the future.

A2.0 CONCLUSIONS AND RECOMMENDATIONS

A2.1 CONCLUSIONS

A review of groundwater monitoring data indicates that a constantly present clean water lens at least 3 ft thick can be defined over most of the current extent of the AV plume south of Ashumet Pond. However, the available data do not indicate the presence of a clean water lens below the Backus River where groundwater discharges to the river and the plume COCs are detected in surface water. Additionally, a 3 ft-thick clean water lens cannot be defined with adequate certainty for the area immediately downgradient (i.e., south) of the FTA-1 source area and in an area along the western shore of Ashumet Pond. Within these areas in the northern plume zone, isolated detections of PCE have been observed in wells screened at or near the water table. Two commercial/industrial use buildings are near the water table PCE detections south of the FTA-1 source area and underground utilities are also present below Kittredge Road (Figure A-7). In the area to the west of Ashumet Pond, a residential property is located approximately 200 ft from a monitoring well where PCE detections were reported and underground utilities are also present below Sandwich Road (Figure A-8). In contrast, no existing buildings are located within 100 ft of the PCE and TCE detections in shallow groundwater below the Backus River; however, it is possible that buildings could be constructed in this area in the future.

In all of the cases where detectable concentrations of VI COPCs (PCE and/or TCE) have been identified at the water table, the concentrations are below the groundwater-to-indoor VI screening values presented in Table 4-1 of the main document. Therefore, the VI pathway is considered insignificant in these areas and the VOCs present in groundwater are considered unlikely to result in VI risks above target levels. In addition, since no ongoing sources are present and long-term monitoring data indicate declining concentration trends throughout the AV plume, higher concentrations are not anticipated in the future.

A2.2 RECOMMENDATIONS

All areas of the AV plume have been evaluated for VI and it has been concluded that VI concerns are unwarranted based on either an incomplete or insignificant exposure pathway. Therefore, no further monitoring or data collection is needed specific to VI. However, as part of

the ongoing remedial actions at the AV plume, AFCEE will continue to monitor the nature and extent of the AV plume under the SPEIM program and will re-evaluate the VI exposure pathway if conditions change such that VI could be a concern.

A3.0 REFERENCES

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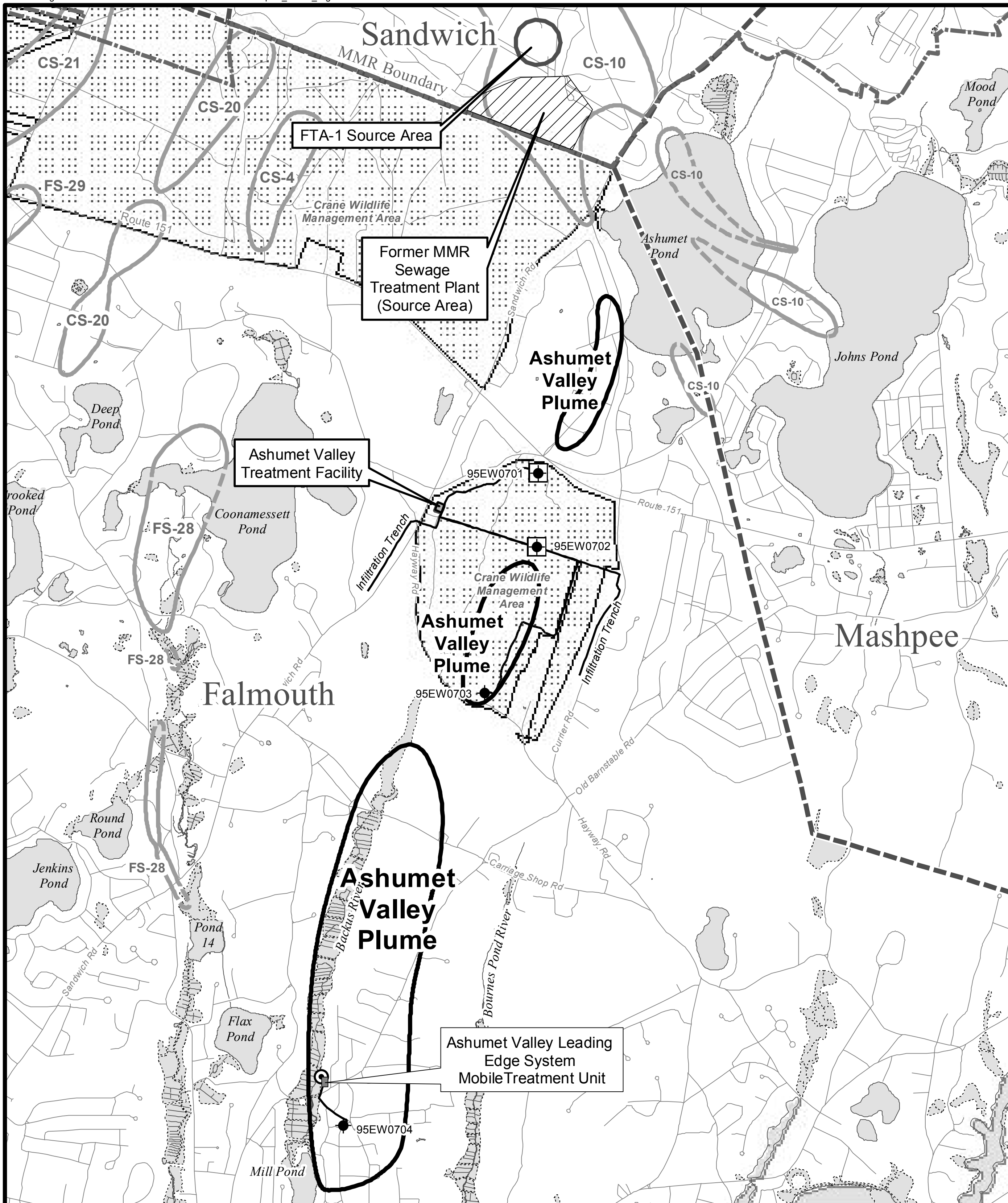


Legend

- Ashumet Valley Plume Boundary
- Other Plume Boundary (Dashed Where Inferred)
- Massachusetts Military Reservation Boundary
- Town Boundary
- Remedial System Pipeline and Treatment Plant
- Discharge Bubbler
- Extraction Well (On)
- Extraction Well (Off)
- Crane Wildlife Management Area
- Bog/Wetland

Data Source: AFCEE, March 2012, MMR-AFCEE Data Warehouse
MMR Boundary from Massachusetts Air National Guard 2011

N

0 1,400 2,800 Feet

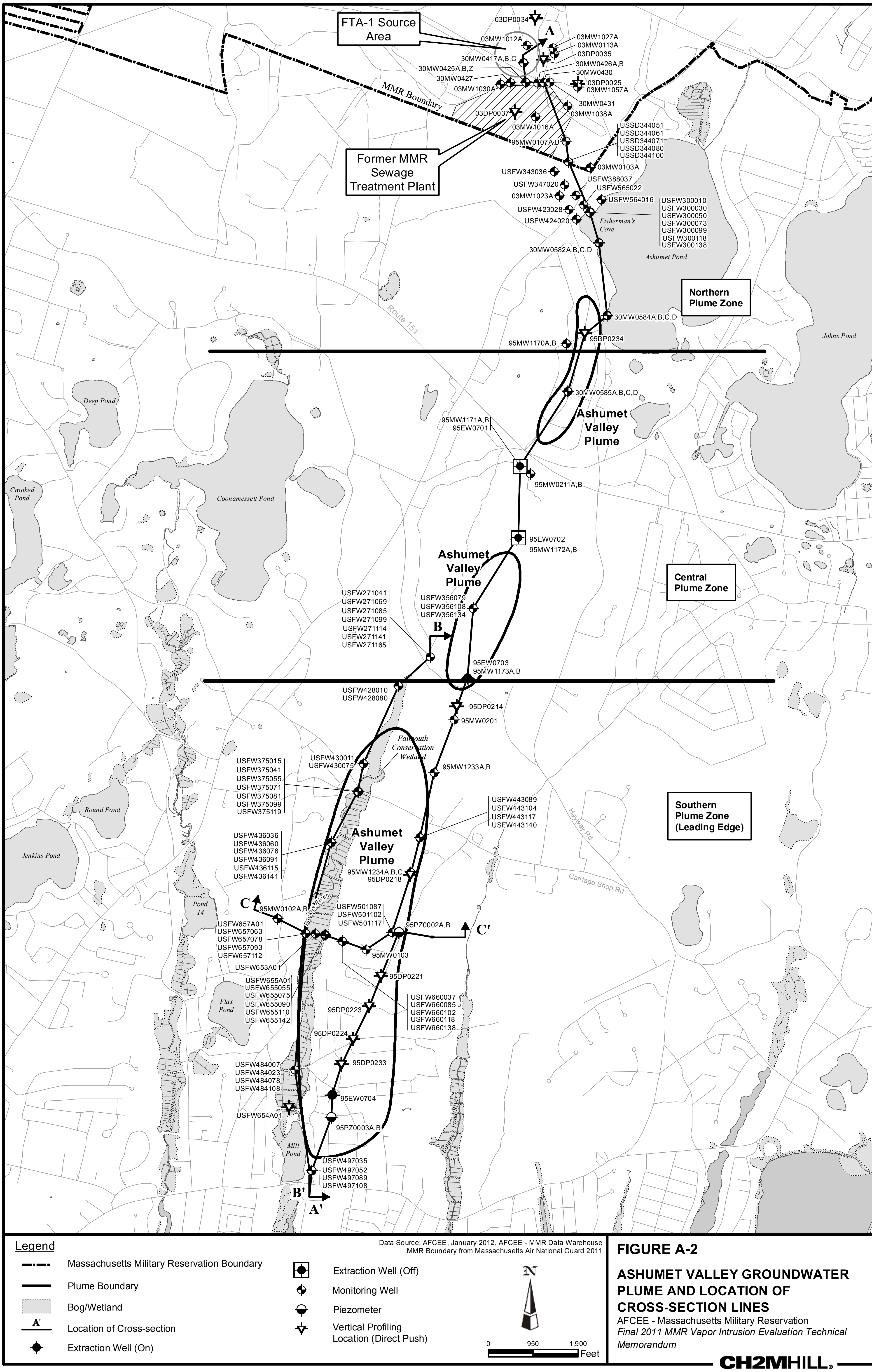
FIGURE A-1

ASHUMET VALLEY GROUNDWATER PLUME AND REMEDIAL SYSTEMS

AFCEE - Massachusetts Military Reservation

Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

CH2MHILL.



Data Source: AFCEE, January 2012, AFCEE - MMR Data Warehouse
MMR Boundary from Massachusetts Air National Guard 2011

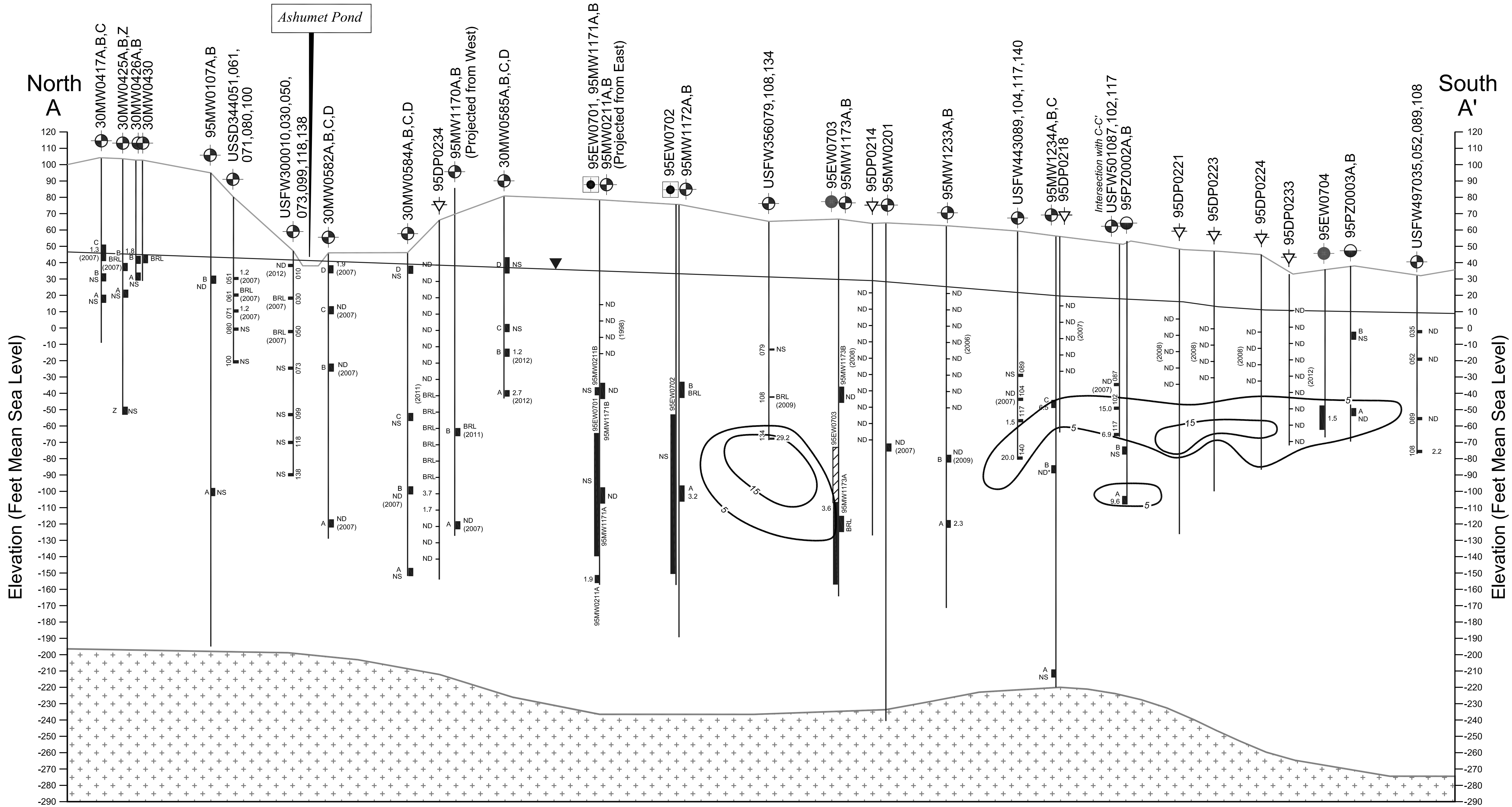
FIGURE A-2

ASHUMET VALLEY GROUNDWATER PLUME AND LOCATION OF CROSS-SECTION LINES

AFCEE - Massachusetts Military Reservation

Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

CH2MHILL



Source: AFCEE, May 2012, MMR-AFCEE Data Warehouse.

Legend

Monitoring Well	Piezometer	2011 PCE Isoconcentration Contour (Dashed Where Inferred)
Extraction Well (On)	Water Table	PCE Groundwater Vertical Profile Results (µg/L) (Date Collected)
Extraction Well (Off)	NS Not Sampled	PCE Results (µg/L) (Collected in 2011 Unless Otherwise Noted)
Direct Push Location	ND Nondetect	Packered Well Screen
	BRL Below Reporting Limit	Well Screen ID
		Bedrock

V: 60
H: 1335
0 Feet

FIGURE A-3

ASHUMET VALLEY
CROSS-SECTION A-A' - PCE
AFCEE - Massachusetts Military Reservation
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

CH2MHILL.

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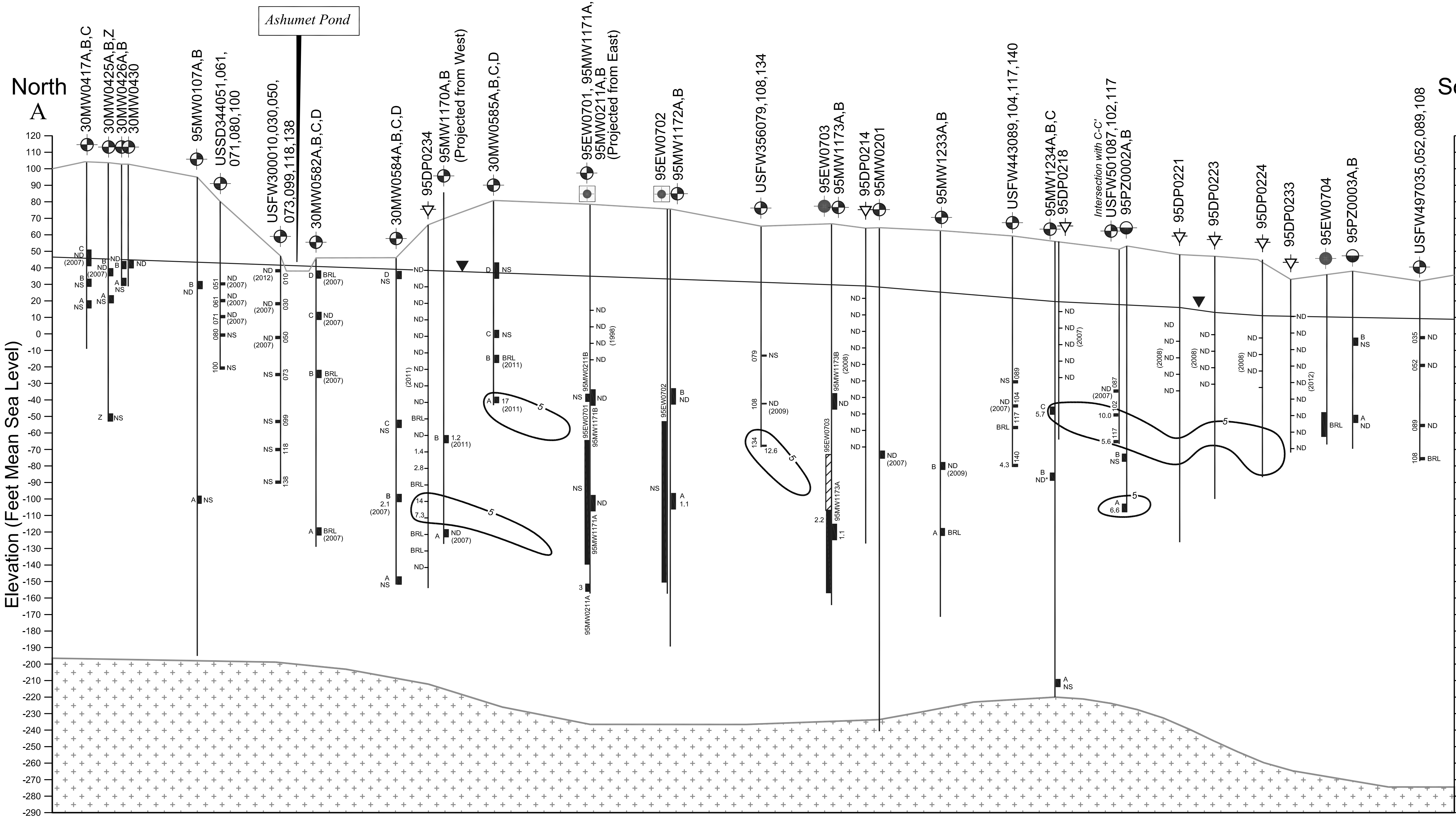


Legend

Monitoring Well	Piezometer
Extraction Well (On)	Water Table
Extraction Well (Off)	NS Not Sampled
Direct Push Location	ND Nondetect
	BRL Below Reporting Limit

—5— 2011 TCE Isoconcentration Contour (Dashed Where Inferred)

15 TCE Results (µg/L) (Collected in 2011 Unless Otherwise Noted)

A 119 Well Screen ID

ND ND TCE Groundwater Vertical Profile Results (µg/L) (Date Collected)

Packered Well Screen

Bedrock

Source: AFCEE, May 2012, MMR-AFCEE Data Warehouse.

V: 60
H: 1335
0 Feet

FIGURE A-4

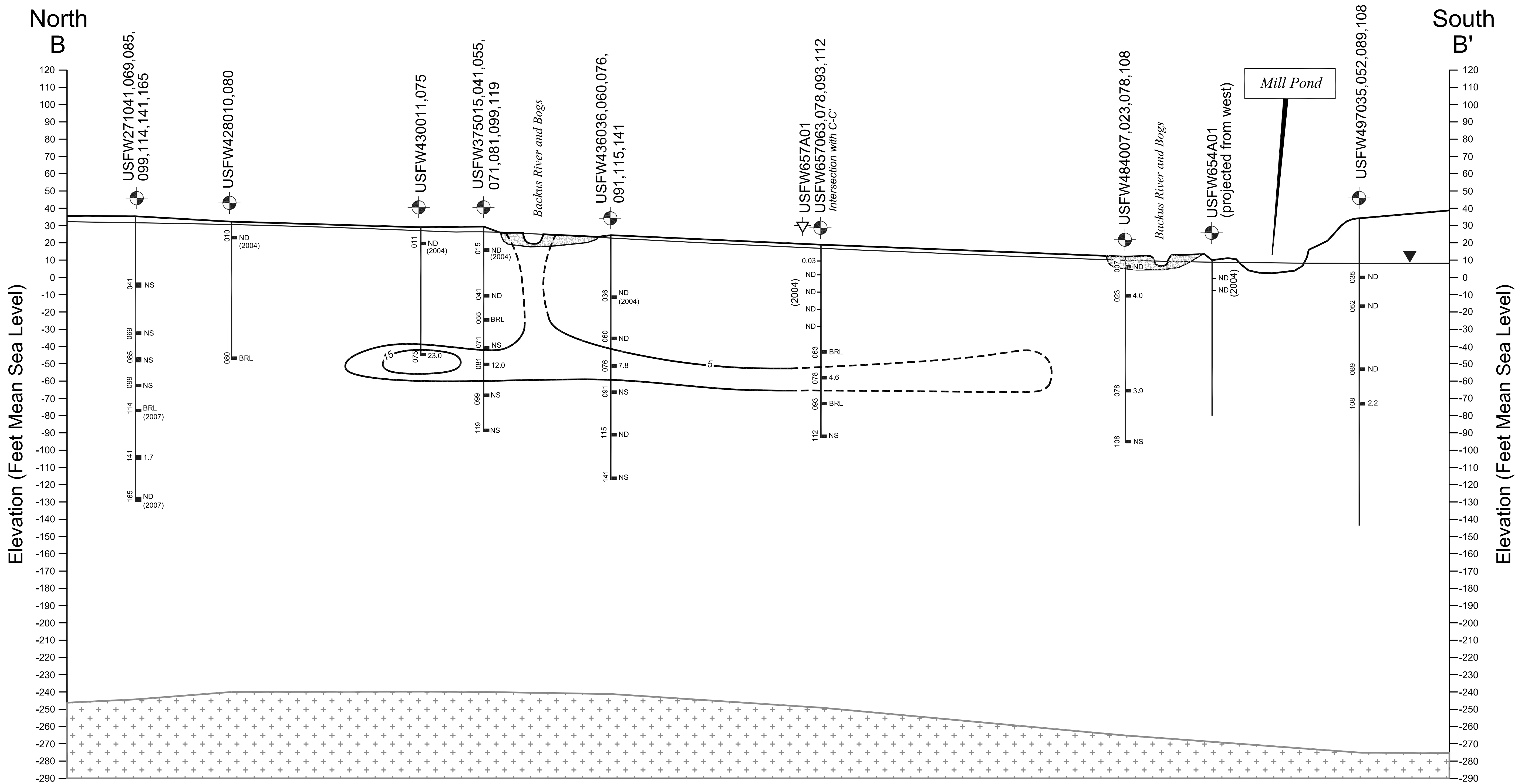
ASHUMET VALLEY
CROSS-SECTION A-A' - TCE

AFCEE - Massachusetts Military Reservation

Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

CH2MHILL

last modified: 06/01/12 printed: 07/12/12 by 12 Y:\Figures\General\2011\VItechmemo\Final\CAD\VI_11TM_FigA-05.dwg



Legend

Monitoring Well	NS	Not Sampled	ND / ND	PCE Groundwater Vertical Profile Results (µg/L) (Collected 2011, Unless Otherwise Noted)	Bedrock
Water Table	BRL	Below Reporting Limit	—5—	2011 PCE Isoconcentration Contour (Dashed Where Inferred)	Bog Sediment
Vertical Profile Location	A 112	Well Screen ID	15	PCE Result (µg/L)	
ND Nondetect					

Source: AFCEE May 2012, MMR-AFCEE Data Warehouse.

V: 60
H: 988
0 Feet

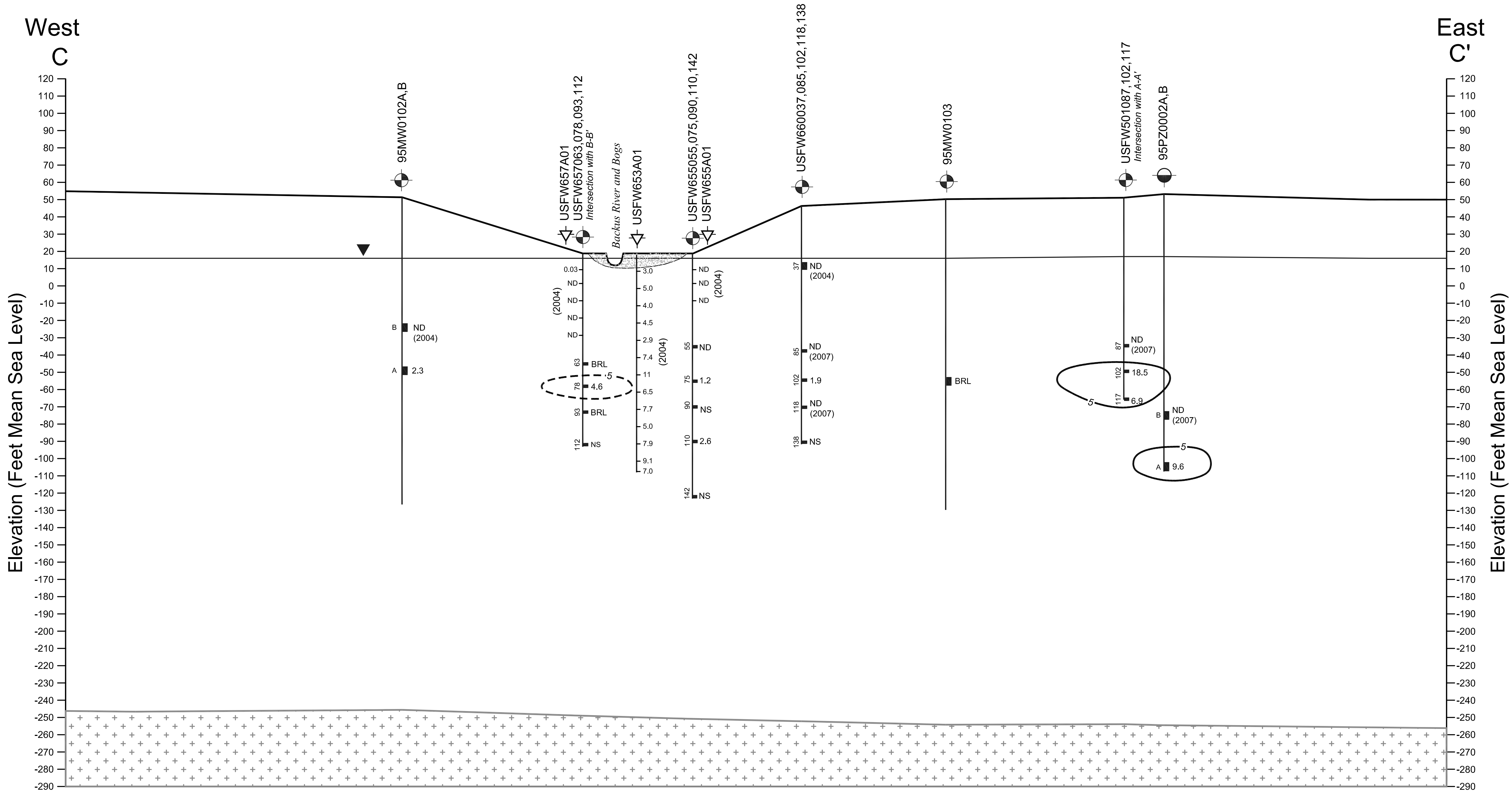
FIGURE A-5

ASHUMET VALLEY CROSS-SECTION B-B' - PCE

AFCEE - Massachusetts Military Reservation

Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

CH2MHILL.



Legend

- Monitoring Well
- Water Table
- Vertical Profile Location
- ND — Nondetect
- NS — Not Sampled
- BRL — Below Reporting Limit
- Well Screen ID
- PCE Groundwater Vertical Profile Results (µg/L) (Collected 2011, Unless Otherwise Noted)
- —5— 2011 PCE Isoconcentration Contour (Dashed Where Inferred)
- 15 PCE Result (µg/L)
- Bedrock
- Bog Sediment

Source: AFCEE May 2012, MMR-AFCEE Data Warehouse.

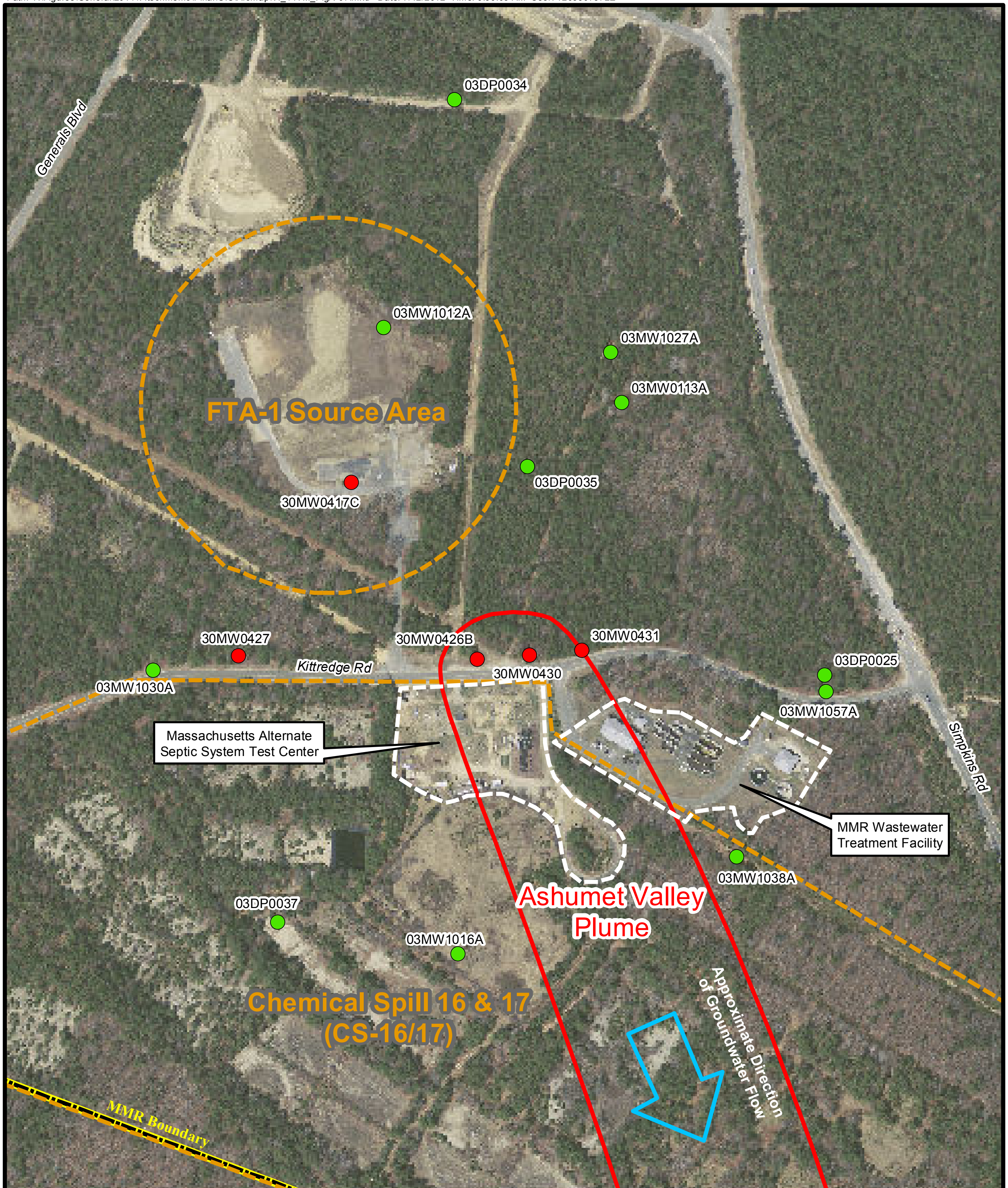
V: 60
H: 383
0 Feet

FIGURE A-6

ASHUMET VALLEY
CROSS-SECTION C-C' - PCE

AFCEE - Massachusetts Military Reservation
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

CH2MHILL



Legend

- Monitoring Well - VI COPC Detected
- Monitoring Well - VI COPC Not Detected
- 2007 Plume Boundary (Added for Reference)
- Massachusetts Military Reservation Boundary
- Source Area Boundary

Data Source: AFCEE, May 2012, MMR-AFCEE Data Warehouse
2009 Aerial Photography from MassGIS

N

0 170 340 Feet

FIGURE A-7

ASHUMET VALLEY SOURCE AREA EXTENT OF WATER TABLE VI COPC DETECTIONS

AFCEE - Massachusetts Military Reservation

Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

CH2MHILL

Legend

- Monitoring Well - VI COPC Detected
- Monitoring Well - VI COPC Not Detected
- 2007 Plume Boundary (Added for Reference)
- Massachusetts Military Reservation Boundary
- Source Area Boundary

Data Source: AFCEE, May 2012, MMR-AFCEE Data Warehouse
2009 Aerial Photography from MassGIS

N

0 170 340 Feet

FIGURE A-8

ASHUMET VALLEY EXTENT OF WATER TABLE VI COPC DETECTIONS NEAR ASHUMET POND

AFCEE - Massachusetts Military Reservation
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

CH2MHILL

Table A-1
Ashumet Valley Groundwater Data Used in Support of VI Evaluation
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Location	Date Sampled	Mid-Sample Elevation (ft msl)	Sampling Method[1]	VI COPC[2]	Result (µg/L)
Source Area Groundwater					
03DP0025	5/11/2004	50	VP	No detections of plume-related VI COPCs	
03DP0025	5/11/2004	40	VP	No detections of plume-related VI COPCs	
03DP0025	5/11/2004	30	VP	No detections of plume-related VI COPCs	
03DP0025	5/11/2004	20	VP	No detections of plume-related VI COPCs	
03DP0025	5/11/2004	10	VP	No detections of plume-related VI COPCs	
03DP0025	5/11/2004	0	VP	No detections of plume-related VI COPCs	
03DP0025	5/11/2004	-10.00	VP	No detections of plume-related VI COPCs	
03DP0025	5/11/2004	-20.00	VP	No detections of plume-related VI COPCs	
03DP0025	5/12/2004	-30.00	VP	No detections of plume-related VI COPCs	
03DP0025	5/12/2004	-40.00	VP	No detections of plume-related VI COPCs	
03DP0025	5/12/2004	-50.00	VP	No detections of plume-related VI COPCs	
03DP0034	1/3/2006	46.97	VP	No detections of plume-related VI COPCs	
03DP0034	1/3/2006	36.97	VP	No detections of plume-related VI COPCs	
03DP0034	1/3/2006	26.97	VP	No detections of plume-related VI COPCs	
03DP0034	1/3/2006	16.97	VP	No detections of plume-related VI COPCs	
03DP0034	1/3/2006	6.97	VP	No detections of plume-related VI COPCs	
03DP0034	1/4/2006	-3.03	VP	No detections of plume-related VI COPCs	
03DP0034	1/4/2006	-13.03	VP	No detections of plume-related VI COPCs	
03DP0034	1/4/2006	-23.03	VP	No detections of plume-related VI COPCs	
03DP0034	1/4/2006	-33.03	VP	No detections of plume-related VI COPCs	
03DP0034	1/4/2006	-43.03	VP	No detections of plume-related VI COPCs	
03DP0035	1/6/2006	41.49	VP	No detections of plume-related VI COPCs	
03DP0035	1/6/2006	31.49	VP	No detections of plume-related VI COPCs	
03DP0035	1/9/2006	21.49	VP	No detections of plume-related VI COPCs	
03DP0035	1/9/2006	1.49	VP	No detections of plume-related VI COPCs	
03DP0035	1/9/2006	-8.51	VP	No detections of plume-related VI COPCs	
03DP0035	1/9/2006	-18.51	VP	No detections of plume-related VI COPCs	
03DP0035	1/9/2006	-28.51	VP	No detections of plume-related VI COPCs	
03DP0035	1/9/2006	-38.51	VP	No detections of plume-related VI COPCs	
03DP0035	1/9/2006	-48.51	VP	No detections of plume-related VI COPCs	
03DP0037	1/16/2006	46.50	VP	No detections of plume-related VI COPCs	
03DP0037	1/17/2006	36.50	VP	No detections of plume-related VI COPCs	
03DP0037	1/17/2006	26.50	VP	No detections of plume-related VI COPCs	
03DP0037	1/17/2006	16.50	VP	No detections of plume-related VI COPCs	
03DP0037	1/17/2006	6.50	VP	No detections of plume-related VI COPCs	
03DP0037	1/17/2006	-3.50	VP	No detections of plume-related VI COPCs	
03DP0037	1/17/2006	-13.50	VP	No detections of plume-related VI COPCs	
03DP0037	1/17/2006	-23.50	VP	No detections of plume-related VI COPCs	
03DP0037	1/17/2006	-33.50	VP	No detections of plume-related VI COPCs	
03DP0037	1/17/2006	-43.50	VP	No detections of plume-related VI COPCs	
03DP0037	1/17/2006	-53.50	VP	No detections of plume-related VI COPCs	
03MW0113A	4/30/1998	31.65	VP	No detections of plume-related VI COPCs	
03MW0113A	4/30/1998	21.65	VP	No detections of plume-related VI COPCs	
03MW0113A	4/30/1998	11.65	VP	No detections of plume-related VI COPCs	
03MW0113A	4/30/1998	1.65	VP	No detections of plume-related VI COPCs	
03MW0113A	4/30/1998	-8.35	VP	No detections of plume-related VI COPCs	
03MW0113A	4/30/1998	-18.35	VP	No detections of plume-related VI COPCs	
03MW0113A	5/1/1998	-28.35	VP	No detections of plume-related VI COPCs	
03MW0113A	5/1/1998	-38.35	VP	No detections of plume-related VI COPCs	
03MW1012A	9/28/2004	35.17	VP	No detections of plume-related VI COPCs	
03MW1012A	9/28/2004	25.17	VP	No detections of plume-related VI COPCs	
03MW1012A	9/28/2004	15.17	VP	No detections of plume-related VI COPCs	
03MW1012A	9/28/2004	5.17	VP	No detections of plume-related VI COPCs	

Table A-1
Ashumet Valley Groundwater Data Used in Support of VI Evaluation
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Location	Date Sampled	Mid-Sample Elevation (ft msl)	Sampling Method[1]	VI COPC[2]	Result (µg/L)
03MW1012A	9/28/2004	-4.83	VP	No detections of plume-related VI COPCs	
03MW1012A	9/28/2004	-14.83	VP	No detections of plume-related VI COPCs	
03MW1016A	1/19/2006	13.35	VP	No detections of plume-related VI COPCs	
03MW1016A	1/19/2006	3.35	VP	No detections of plume-related VI COPCs	
03MW1016A	1/19/2006	-6.65	VP	No detections of plume-related VI COPCs	
03MW1016A	1/19/2006	-16.65	VP	No detections of plume-related VI COPCs	
03MW1016A	1/19/2006	-26.65	VP	No detections of plume-related VI COPCs	
03MW1027A	10/23/2006	42.18	VP	No detections of plume-related VI COPCs	
03MW1027A	10/23/2006	32.18	VP	No detections of plume-related VI COPCs	
03MW1027A	10/24/2006	22.18	VP	No detections of plume-related VI COPCs	
03MW1027A	10/24/2006	12.18	VP	No detections of plume-related VI COPCs	
03MW1027A	10/24/2006	2.18	VP	No detections of plume-related VI COPCs	
03MW1027A	10/24/2006	-7.82	VP	No detections of plume-related VI COPCs	
03MW1027A	10/24/2006	-17.82	VP	No detections of plume-related VI COPCs	
03MW1027A	10/24/2006	-27.82	VP	No detections of plume-related VI COPCs	
03MW1027A	10/24/2006	-37.82	VP	No detections of plume-related VI COPCs	
03MW1027A	10/24/2006	-47.82	VP	No detections of plume-related VI COPCs	
03MW1030A	12/19/2006	43.47	VP	No detections of plume-related VI COPCs	
03MW1030A	12/19/2006	33.47	VP	No detections of plume-related VI COPCs	
03MW1030A	12/19/2006	23.47	VP	No detections of plume-related VI COPCs	
03MW1030A	12/19/2006	13.47	VP	No detections of plume-related VI COPCs	
03MW1030A	12/19/2006	3.47	VP	No detections of plume-related VI COPCs	
03MW1030A	12/19/2006	-6.53	VP	No detections of plume-related VI COPCs	
03MW1030A	12/20/2006	-16.53	VP	No detections of plume-related VI COPCs	
03MW1030A	12/20/2006	-26.53	VP	No detections of plume-related VI COPCs	
03MW1030A	12/20/2006	-36.53	VP	No detections of plume-related VI COPCs	
03MW1030A	12/20/2006	-46.53	VP	No detections of plume-related VI COPCs	
03MW1030A	12/20/2006	-56.53	VP	No detections of plume-related VI COPCs	
03MW1038A	10/23/2007	41.49	VP	No detections of plume-related VI COPCs	
03MW1038A	10/23/2007	31.49	VP	No detections of plume-related VI COPCs	
03MW1038A	10/23/2007	21.49	VP	No detections of plume-related VI COPCs	
03MW1038A	10/23/2007	11.49	VP	No detections of plume-related VI COPCs	
03MW1038A	10/23/2007	1.49	VP	No detections of plume-related VI COPCs	
03MW1038A	10/23/2007	-8.51	VP	No detections of plume-related VI COPCs	
03MW1038A	10/24/2007	-18.51	VP	No detections of plume-related VI COPCs	
03MW1038A	10/24/2007	-28.51	VP	No detections of plume-related VI COPCs	
03MW1038A	10/24/2007	-38.51	VP	No detections of plume-related VI COPCs	
03MW1038A	10/24/2007	-48.51	VP	No detections of plume-related VI COPCs	
03MW1038A	10/24/2007	-58.51	VP	No detections of plume-related VI COPCs	
03MW1038A	10/24/2007	-68.51	VP	No detections of plume-related VI COPCs	
03MW1038A	10/25/2007	-78.51	VP	No detections of plume-related VI COPCs	
03MW1038A	10/25/2007	-88.51	VP	No detections of plume-related VI COPCs	
03MW1038A	10/25/2007	-98.51	VP	No detections of plume-related VI COPCs	
03MW1038A	10/25/2007	-108.51	VP	No detections of plume-related VI COPCs	
03MW1038A	10/26/2007	-118.51	VP	No detections of plume-related VI COPCs	
03MW1057A	11/11/2009	45.50	VP	No detections of plume-related VI COPCs	
03MW1057A	11/11/2009	35.50	VP	No detections of plume-related VI COPCs	
03MW1057A	11/11/2009	25.50	VP	No detections of plume-related VI COPCs	
03MW1057A	11/11/2009	15.50	VP	No detections of plume-related VI COPCs	
03MW1057A	11/11/2009	5.50	VP	No detections of plume-related VI COPCs	
03MW1057A	11/12/2009	-4.50	VP	No detections of plume-related VI COPCs	
03MW1057A	11/12/2009	-14.50	VP	No detections of plume-related VI COPCs	
03MW1057A	11/12/2009	-24.50	VP	No detections of plume-related VI COPCs	
03MW1057A	11/12/2009	-34.50	VP	No detections of plume-related VI COPCs	

Table A-1
Ashumet Valley Groundwater Data Used in Support of VI Evaluation
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Location	Date Sampled	Mid-Sample Elevation (ft msl)	Sampling Method[1]	VI COPC[2]	Result (µg/L)
03MW1057A	11/12/2009	-44.50	VP	No detections of plume-related VI COPCs	
03MW1057A	11/13/2009	-54.50	VP	No detections of plume-related VI COPCs	
30MW0417C	9/18/2007	47.32	MW	PCE	1.3
30MW0426B	12/29/2010	41.70	MW	PCE	1.8
30MW0427	10/23/1998	41.72	MW	PCE	1.5
30MW0430	12/29/2010	42.12	MW	PCE	BRL
30MW0431	4/22/2004	48.75	MW	PCE	5.7
Western Shore of Ashumet Pond					
03MW0103A	4/6/1998	32.74	VP	No detections of plume-related VI COPCs	
03MW0103A	4/6/1998	22.74	VP	No detections of plume-related VI COPCs	
03MW0103A	4/6/1998	12.74	VP	No detections of plume-related VI COPCs	
03MW0103A	4/6/1998	2.74	VP	No detections of plume-related VI COPCs	
03MW0103A	4/6/1998	-7.26	VP	No detections of plume-related VI COPCs	
03MW0103A	4/6/1998	-17.26	VP	No detections of plume-related VI COPCs	
03MW0103A	4/7/1998	-27.26	VP	No detections of plume-related VI COPCs	
03MW0103A	4/7/1998	-37.26	VP	No detections of plume-related VI COPCs	
03MW0103A	4/7/1998	-47.26	VP	No detections of plume-related VI COPCs	
03MW0103A	4/7/1998	-57.26	VP	No detections of plume-related VI COPCs	
03MW0103A	4/7/1998	-67.26	VP	No detections of plume-related VI COPCs	
03MW0103A	4/7/1998	-77.26	VP	No detections of plume-related VI COPCs	
03MW0103A	4/8/1998	-87.26	VP	No detections of plume-related VI COPCs	
03MW0103A	4/8/1998	-97.26	VP	No detections of plume-related VI COPCs	
03MW0103A	4/8/1998	-107.26	VP	No detections of plume-related VI COPCs	
03MW0103A	4/8/1998	-117.26	VP	No detections of plume-related VI COPCs	
03MW0103A	4/9/1998	-127.26	VP	No detections of plume-related VI COPCs	
03MW0103A	4/9/1998	-137.26	VP	No detections of plume-related VI COPCs	
03MW0103A	4/9/1998	-147.26	VP	No detections of plume-related VI COPCs	
03MW0103A	4/9/1998	-157.26	VP	No detections of plume-related VI COPCs	
03MW0103A	4/14/1998	-167.26	VP	No detections of plume-related VI COPCs	
03MW0103A	4/14/1998	-172.26	VP	No detections of plume-related VI COPCs	
03MW1023A	12/5/2006	27.88	VP	No detections of plume-related VI COPCs	
USFW300010	4/23/2012	38.30	MW	No detections of plume-related VI COPCs	
USFW343036	9/19/2005	33.51	MW	No detections of plume-related VI COPCs	
USFW347020	10/26/1998	40.98	MW	PCE	BRL
USFW388037	4/23/2012	33.18	MW	PCE	BRL
USFW423028	4/23/2012	63.65	MW	No detections of plume-related VI COPCs	
USFW424020	7/19/1999	41.33	MW	No detections of plume-related VI COPCs	
USFW564016	9/12/2007	43.70	MW	No detections of plume-related VI COPCs	
USFW565022	4/23/2012	48.56	MW	No detections of plume-related VI COPCs	
AV Plume South of Ashumet Pond					
95DP0214	2/8/2006	21.50	VP	No detections of plume-related VI COPCs	
95DP0214	2/8/2006	11.50	VP	No detections of plume-related VI COPCs	
95DP0214	2/8/2006	1.50	VP	No detections of plume-related VI COPCs	
95DP0214	2/8/2006	-8.50	VP	No detections of plume-related VI COPCs	
95DP0214	2/8/2006	-18.50	VP	No detections of plume-related VI COPCs	
95DP0214	2/8/2006	-28.50	VP	No detections of plume-related VI COPCs	
95DP0214	2/8/2006	-38.50	VP	No detections of plume-related VI COPCs	
95DP0214	2/8/2006	-48.50	VP	No detections of plume-related VI COPCs	
95DP0214	2/8/2006	-58.50	VP	No detections of plume-related VI COPCs	
95DP0214	2/8/2006	-68.50	VP	No detections of plume-related VI COPCs	
95DP0218	12/13/2007	13.50	VP	No detections of plume-related VI COPCs	
95DP0218	12/13/2007	3.50	VP	No detections of plume-related VI COPCs	
95DP0218	12/13/2007	3.50	VP	No detections of plume-related VI COPCs	

Table A-1
Ashumet Valley Groundwater Data Used in Support of VI Evaluation
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Location	Date Sampled	Mid-Sample Elevation (ft msl)	Sampling Method[1]	VI COPC[2]	Result (µg/L)
95DP0218	12/13/2007	-6.50	VP	No detections of plume-related VI COPCs	
95DP0218	12/17/2007	-16.50	VP	No detections of plume-related VI COPCs	
95DP0218	12/17/2007	-26.50	VP	No detections of plume-related VI COPCs	
95DP0221	1/15/2008	5.50	VP	No detections of plume-related VI COPCs	
95DP0221	1/15/2008	-4.50	VP	No detections of plume-related VI COPCs	
95DP0221	1/17/2008	-14.50	VP	No detections of plume-related VI COPCs	
95DP0221	1/17/2008	-24.50	VP	No detections of plume-related VI COPCs	
95DP0221	1/17/2008	-34.50	VP	No detections of plume-related VI COPCs	
95DP0223	2/12/2008	-0.50	VP	No detections of plume-related VI COPCs	
95DP0223	2/12/2008	-10.50	VP	No detections of plume-related VI COPCs	
95DP0223	2/14/2008	-20.50	VP	No detections of plume-related VI COPCs	
95DP0223	2/14/2008	-30.50	VP	No detections of plume-related VI COPCs	
95DP0224	2/20/2008	-2.50	VP	No detections of plume-related VI COPCs	
95DP0224	2/20/2008	-12.50	VP	No detections of plume-related VI COPCs	
95DP0224	2/20/2008	-22.50	VP	No detections of plume-related VI COPCs	
95DP0224	2/20/2008	-32.50	VP	No detections of plume-related VI COPCs	
95DP0233	1/17/2012	10.50	VP	No detections of plume-related VI COPCs	
95DP0233	1/17/2012	0.50	VP	No detections of plume-related VI COPCs	
95DP0233	1/17/2012	-9.50	VP	No detections of plume-related VI COPCs	
95DP0233	1/19/2012	-19.50	VP	No detections of plume-related VI COPCs	
95DP0233	1/19/2012	-29.50	VP	No detections of plume-related VI COPCs	
95DP0233	1/19/2012	-39.50	VP	No detections of plume-related VI COPCs	
95DP0233	1/19/2012	-49.50	VP	No detections of plume-related VI COPCs	
95DP0233	1/19/2012	-59.50	VP	No detections of plume-related VI COPCs	
95DP0233	1/20/2012	-69.50	VP	No detections of plume-related VI COPCs	
95DP0234	12/6/2011	38.50	VP	No detections of plume-related VI COPCs	
95DP0234	12/6/2011	28.50	VP	No detections of plume-related VI COPCs	
95DP0234	12/6/2011	18.50	VP	No detections of plume-related VI COPCs	
95DP0234	12/6/2011	8.50	VP	No detections of plume-related VI COPCs	
95DP0234	12/6/2011	-1.50	VP	No detections of plume-related VI COPCs	
95DP0234	12/7/2011	-11.50	VP	No detections of plume-related VI COPCs	
95DP0234	12/7/2011	-21.50	VP	No detections of plume-related VI COPCs	
95DP0234	12/7/2011	-31.50	VP	No detections of plume-related VI COPCs	
95MW0211A	7/10/1998	14.27	VP	No detections of plume-related VI COPCs	
95MW0211A	7/10/1998	4.27	VP	No detections of plume-related VI COPCs	
95MW0211A	7/10/1998	-5.73	VP	No detections of plume-related VI COPCs	
95MW0211A	7/10/1998	-15.73	VP	No detections of plume-related VI COPCs	
95MW1233A	3/24/2003	21.09	VP	No detections of plume-related VI COPCs	
95MW1233A	3/24/2003	11.09	VP	No detections of plume-related VI COPCs	
95MW1233A	3/24/2003	1.09	VP	No detections of plume-related VI COPCs	
95MW1233A	3/24/2003	-8.91	VP	No detections of plume-related VI COPCs	
95MW1233A	3/25/2003	-18.91	VP	No detections of plume-related VI COPCs	
95MW1233A	3/25/2003	-28.91	VP	No detections of plume-related VI COPCs	
95MW1233A	3/25/2003	-38.91	VP	No detections of plume-related VI COPCs	
95MW1233A	3/25/2003	-48.91	VP	No detections of plume-related VI COPCs	

Table A-1
Ashumet Valley Groundwater Data Used in Support of VI Evaluation
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Location	Date Sampled	Mid-Sample Elevation (ft msl)	Sampling Method[1]	VI COPC[2]	Result (µg/L)
AV Plume in the Vicinity of Backus River					
USFW375015	10/25/2004	15.81	MW	No detections of plume-related VI COPCs	
USFW375041	4/8/2010	-10.65	MW	No detections of plume-related VI COPCs	
USFW428010	11/2/2004	22.99	MW	No detections of plume-related VI COPCs	
USFW430011	11/2/2004	19.61	MW	No detections of plume-related VI COPCs	
USFW436036	10/21/2004	-10.30	MW	No detections of plume-related VI COPCs	
USFW484007	8/16/2011	6.01	MW	No detections of plume-related VI COPCs	
USFW497035	4/8/2010	0.14	MW	No detections of plume-related VI COPCs	
USFW653A01*	8/17/2004	8.50	VP	PCE	3.0
USFW653A01*	8/17/2004	8.50	VP	TCE	2.2
USFW654A01*	8/17/2004	0.50	VP	No detections of plume-related VI COPCs	
USFW654A01*	8/17/2004	-7.50	VP	No detections of plume-related VI COPCs	
USFW655A01*	8/18/2004	8.50	VP	No detections of plume-related VI COPCs	
USFW655A01*	8/18/2004	0.50	VP	No detections of plume-related VI COPCs	
USFW655A01*	8/18/2004	-9.50	VP	No detections of plume-related VI COPCs	
USFW657A01*	8/19/2004	7.50	VP	PCE	0.03

Data Source: AFCEE, May 2012, MMR-AFCEE Data Warehouse.
* Data for locations USFW653A01, USFW655A01, and USFW657A01 are from a U.S. Geological Survey investigation conducted in 2004 and are reported as screening level data in the MMR-AFCEE Data Warehouse. Only TCE and PCE were analyzed during this event and analysis was performed at an on-site mobile laboratory operated by the U.S. Environmental Protection Agency.

Notes:
1. Sample collection method:
VP = vertical profile groundwater sampling (direct push, rotosonic, or screened hollow-stem auger drilling methods)
MW = fixed monitoring well
2. See Table 4-1 of the main document for a complete list of VI COPCs.

The data summarized in this table specifically support the AV plume clean water lens VI evaluation and typically include the most recent sampling results for each location for the plume-related VI COPCs only. If additional historic sampling data exist, they are available for review in the AFCEE-MMR Data Warehouse.

Vertical profile data presented only include the relevant sample intervals used to support this AV plume VI evaluation; analytical data from deeper sample intervals are available in the AFCEE MMR Data Warehouse.

Key:

AV = Ashumet Valley
BRL = below reporting limit of 1 microgram per liter
COPC = contaminant of potential concern
ft msl = feet mean sea level
NA = not applicable
ND = not detected
PCE = tetrachloroethene
TCE = trichloroethene
VI = vapor intrusion
µg/L = micrograms per liter

Table A-2
Ashumet Valley Well Construction and Sample Location Information
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Location	Northing (ft)	Easting (ft)	Surface Elevation (ft msl)	Measuring Point Elevation (ft msl)	Total Well Depth (ft bgs)	Top Screen Depth (ft bgs)	Bottom Screen Depth (ft bgs)	Top Screen Elevation (ft msl)	Bottom Screen Elevation (ft msl)	Screen Length (ft)
03DP0025	235499	862086	95	NA	NA	NA	NA	NA	NA	NA
03DP0034	236893	861189	109	NA	NA	NA	NA	NA	NA	NA
03DP0035	236005	861365	104	NA	NA	NA	NA	NA	NA	NA
03DP0037	234902	860760	54	NA	NA	NA	NA	NA	NA	NA
03MW0103A	233758	862356	65	64.87	235	230.00	235.00	-164.76	-169.76	5
03MW0113A	236160	861594	94	96.30	255	250.00	255.00	-155.85	-160.85	5
03MW1012A	236342	861017	108	109.83	256	250.00	255.00	-142.33	-147.33	5
03MW1016A	234825	861198	86	85.47	206	201.03	205.60	-115.18	-119.75	5
03MW1023A	233162	861704	60	59.73	251	245.29	250.00	-184.91	-189.62	5
03MW1027A	236282	861568	100	99.37	189	184.07	189.07	-84.39	-89.39	5
03MW1030A	235512	860459	101	100.00	260	255.00	260.00	-154.03	-159.03	5
03MW1038A	235060	861872	99	98.28	250	245.38	250.38	-146.71	-151.71	5
03MW1057A	235459	862089	88	NA	NA	NA	NA	NA	NA	NA
30MW0417C	235967	860938	106	107.42	63	53.10	63.30	52.42	42.22	10
30MW0426B	235538	861245	103	104.80	64	58.60	63.60	44.20	39.20	5
30MW0427	235547	860666	100	103.22	61	56.00	61.00	44.22	39.22	5
30MW0430	235548	861371	103	105.62	63	58.00	63.00	44.62	39.62	5
30MW0431	235559	861498	101	103.60	57	47.00	57.00	53.75	43.75	10
95DP0214	222344	859526	64	NA	NA	NA	NA	NA	NA	NA
95DP0218	218788	858545	56	NA	NA	NA	NA	NA	NA	NA
95DP0221	216647	857924	48	NA	NA	NA	NA	NA	NA	NA
95DP0223	216006	857681	47	NA	NA	NA	NA	NA	NA	NA
95DP0224	215315	857342	45	NA	NA	NA	NA	NA	NA	NA
95DP0233	214777	857095	33	NA	NA	NA	NA	NA	NA	NA
95DP0234	230229	862236	66	NA	NA	NA	NA	NA	NA	NA
95MW0211A	227278	861084	79	78.53	236	230.00	235.00	-151.23	-156.23	5
95MW1233A	220969	859049	63	61.96	185	180.17	184.98	-117.58	-122.39	5
USFW300010	232813	862342	47	48.23	10	7.93	9.93	39.30	37.30	2
USFW343036	233668	861593	69	69.21	36	34.40	36.40	34.51	32.51	2
USFW347020	233388	861816	60	60.68	20	17.70	19.70	41.98	39.98	2
USFW375015	220572	857440	29	30.15	15	12.60	14.60	16.81	14.81	2
USFW375041	220566	857447	29	30.21	41	39.00	41.00	-9.65	-11.65	2
USFW388037	233167	862054	69	70.18	37	34.60	36.60	34.18	32.18	2
USFW423028	232862	861906	64	64.15	28	26.00	28.00	37.65	35.65	2
USFW424020	232661	862060	58	58.43	19	14.20	19.20	43.83	38.83	5
USFW428010	222800	858296	32	33.79	10	8.30	10.30	23.99	21.99	2
USFW430011	221157	857555	30	30.71	11	9.10	11.10	20.61	18.61	2
USFW436036	219490	856882	24	25.97	36	33.70	35.70	-9.30	-11.30	2
USFW484007	214682	856118	12	12.14	7	5.40	7.40	7.01	5.01	2
USFW497035	212550	856463	34	35.15	35	33.22	35.22	1.14	-0.86	2
USFW564016	233072	862587	55	56.40	16	6.70	15.70	48.20	39.20	9
USFW565022	232964	862214	61	62.57	22	12.70	21.70	48.56	39.56	9
USFW653A01	217564	856539	18	NA	NA	NA	NA	NA	NA	NA
USFW654A01	213870	855977	10	NA	NA	NA	NA	NA	NA	NA
USFW655A01	217527	856734	18	NA	NA	NA	NA	NA	NA	NA
USFW657A01	217589	856342	17	NA	NA	NA	NA	NA	NA	NA

Data Source: AFCEE, May 2012, MMR-AFCEE Data Warehouse

Key:

bgs = below ground surface

ft = feet

msl = mean sea level

NA = data not available; locations are direct push vertical profile locations and have no screen information.

Table A-3
Comparison of Ashumet Valley PCE and TCE Concentrations in Shallow Groundwater to VI Screening Values
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Location	Date	Mid-Sample Elevation (ft msl)	Laboratory Analyses PCE (µg/L) MCL[1] = 5	MCP Method 1 GW-2 Standard[2] (µg/L)	VI Screening Value Exceeded?	Generic Unrestricted Groundwater VI Screening Value[3] (µg/L)	VI Screening Value Exceeded?
AV Plume Source Area Groundwater							
30MW0417C	9/18/2007	47.32	1.3	50	No	13	No
30MW0426B	12/29/2010	41.70	1.8	50	No	13	No
30MW0427	10/23/1998	41.72	1.5	50	No	13	No
30MW0430	12/29/2010	42.12	BRL	50	No	13	No
30MW0431	4/22/2004	48.75	5.7	50	No	13	No
Western Shore of Ashumet Pond							
USFW347020	10/26/1998	40.98	BRL	50	No	13	No
USFW388037	4/23/2012	33.18	BRL	50	No	13	No
AV Plume in the Vicinity of Backus River and Bogs							
USFW653A01	8/17/2004	8.50	3.0	50	No	13	No
USFW657A01	8/19/2004	7.50	0.03	50	No	13	No
Location	**Date**	**Mid-Sample Elevation (ft msl)**	**Laboratory Analyses TCE (µg/L) MCL[1] = 5**	**MCP Method 1 GW-2 Standard[2] (µg/L)**	**VI Screening Value Exceeded?**	**Generic Unrestricted Groundwater VI Screening Value[3] (µg/L)**	**VI Screening Value Exceeded?**
AV Plume in the Vicinity of Backus River							
USFW653A01	8/17/2004	8.50	2.2	30	No	5	No

Data Source: AFCEE, May 2012, MMR-AFCEE Data Warehouse

Notes:
1. MCL from United States Environmental Protection Agency (EPA) web page, http://water.epa.gov/drink/contaminants/index.cfm
2. 310 CMR 40.0974(2) http://www.mass.gov/dep/cleanup/laws/0974_2.htm .
3. EPA, 2002, Draft Guidance for Evaluating the VI to Indoor Air Pathway from Groundwater and Soils http://www.epa.gov/osw/hazard/correctiveaction/eis/vapor/complete.pdf, using target risk levels of $1x10^{-6}$ excess lifetime cancer risk and noncancer hazard quotient of 0.1 in accordance with best practices for vapor intrusion screening to account for cumulative effects from multiple chemicals. Values updated based on EPA's May 2012 Regional Screening Levels (Residential Indoor Air) for Chemical Contaminants at Superfund Sites http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm.

Key:
AV = Ashumet Valley
BRL = below reporting limit of 1 microgram per liter
ft msl = feet mean sea level
MCL = Maximum Contaminant Level
PCE = tetrachloroethene
TCE = trichloroethene
VI = vapor intrusion
µg/L = micrograms per liter

APPENDIX B

CS-4 Vapor Intrusion Evaluation

TABLE OF CONTENTS

Figures

Tables

ACRONYMS AND ABBREVIATIONS

AFCEE	Air Force Center for Engineering and the Environment
bgs	below ground surface
COC	contaminant of concern
CS	Chemical Spill
CSM	Conceptual Site Model
EDB	ethylene dibromide
FS	Fuel Spill
ft	feet/foot
gpm	gallons per minute
HATF	Hunter Avenue Treatment Facility
MassDEP	Massachusetts Department of Environmental Protection
MCL	Maximum Contaminant Level
MMR	Massachusetts Military Reservation
msl	mean sea level
PCE	tetrachloroethene
RI	Remedial Investigation
SPEIM	System Performance and Ecological Impact Monitoring
TCE	trichloroethene
VI	vapor intrusion
VOC	volatile organic compound
µg/L	micrograms per liter
1,1,2,2-TeCA	1,1,2,2-tetrachloroethane

B1.0 CHEMICAL SPILL-4 VAPOR INTRUSION EVALUATION

B1.1 CS-4 CONCEPTUAL SITE MODEL

The Chemical Spill–4 (CS-4) groundwater plume is a dilute dissolved-phase groundwater plume located south of the Massachusetts Military Reservation (MMR) in Falmouth, Massachusetts (Figure 1-2 of main document), which is detached from its source area. The CS-4 plume (Figures B-1 and B-2) is currently defined as the extent of groundwater containing the primary groundwater contaminant of concern (COC), tetrachloroethene (PCE), at concentrations greater than the Maximum Contaminant Level (MCL) of 5 micrograms per liter (µg/L). The other CS-4 groundwater COCs are trichloroethene (TCE), 1,1,2,2-tetrachloroethane (1,1,2,2-TeCA), and ethylene dibromide (EDB) (AFCEE 2000). TCE concentrations greater than the MCL of 5 µg/L and 1,1,2,2-TeCA concentrations greater than the Massachusetts Department of Environmental Protection (MassDEP) Massachusetts Contingency Plan Method 1 Groundwater-1 standard of 2 µg/L are generally limited in extent and, where present, are co-located with PCE concentrations greater than the MCL. EDB has not been detected above the Massachusetts MCL of 0.02 µg/L in CS-4 groundwater since 2002 (AFCEE 2011a).

The source area for the CS-4 plume is located near the intersection of West Truck Road and Gaffney Road and consists of a former motor pool used from 1941 to 1973 and a Defense Reutilization and Marketing Office that operated from 1956 to 1983 (Figure B-2). Spills, leaks, and disposal in these on-base areas resulted in the CS-4 groundwater plume which has migrated in the aquifer and is now located entirely off-base beneath the Crane Wildlife Management Area just north of Route 151 (Figure B-2) (AFCEE 2008a). Remedial actions at the source area were completed in 2002 (AFCEE 2008a) and monitoring data confirm no ongoing source of groundwater contamination exists at CS-4. Furthermore, characterization data collected within the footprint of the former CS-4 source area (Figure B-2) during the CS-10 in-plume data gap investigation confirm that no residual CS-4 related groundwater contamination exists in this area (AFCEE 2012b, 2011c, 2010, 2009).

A plan view of the CS-4 plume, along with the location of the line of cross-section and monitoring locations used to support this vapor intrusion (VI) evaluation, are shown on Figure B-3. A cross-sectional view of the CS-4 PCE plume is provided as Figure B-4.

Based on the most recent depiction of the CS-4 plume boundary, the plume is approximately 3,000 feet (ft) long and a maximum of 800 ft wide. The CS-4 plume extends from approximately 1,000 ft south-southwest of the MMR base boundary in the Crane Wildlife Management Area to the locations of extraction wells 02EW0014 and 02EW00015, which are located approximately 350 ft north of Route 151 (Figures B-2 and B-3). Characteristic of many of the MMR groundwater plumes, the CS-4 plume descended in the aquifer as it migrated from its source area due to recharge accretion, which has resulted in the plume being located relatively deep in the aquifer and entirely overlain by a lens of clean groundwater. The CS-4 plume is up to 60 ft thick in the aquifer and the upper boundary of the plume is between approximately 110 and 170 ft below ground surface (bgs) and between 60 and 120 ft below the water table (Figures B-3 and B-4). The depiction of the plume shown in cross sectional view on Figure B-4 is based on data collected in 2011, whereas the plume boundary shown on Figures B-1, B-2, and B-3 is based on data collected in 2010.

The topography of the land above the CS-4 plume footprint is generally flat with a ground elevation change of approximately 20 ft from north to south. Sub-regionally, the area is characterized by low rolling hills and flat areas of the Mashpee Pitted Plain, which is a broad, flat, gently southward-sloping glacial outwash plain (AFCEE 2000). Within the footprint of the plume, the maximum and minimum ground surface elevations are approximately 102 ft mean sea level (msl), and 88 ft msl, respectively.

The groundwater flow direction in the vicinity of the CS-4 plume is generally to the south-southwest and flow within the aquifer is primarily horizontal. The depth to groundwater above and in the vicinity of the CS-4 plume ranges from approximately 30 to 55 ft bgs; the elevation of the water table within the CS-4 area ranges from approximately 50 ft msl in the north to 45 ft msl in the south near the operating extraction wells. The aquifer saturated thickness in the CS-4 area is approximately 210 to 230 ft.

The original CS-4 remedial system was installed as an interim remedial action and became operational in 1993 (AFCEE 2008a). Thirteen extraction wells were used to capture the CS-4 plume, arranged in a fence configuration perpendicular to the direction of groundwater flow. Extracted water was treated at the original design flow rate of 195 gallons per minute (gpm). Results of the Southwest Plumes Remedial Investigation (RI) indicated that the original extraction system was not capturing the entire CS-4 plume (AFCEE 1999). The Air Force Center for Engineering and the Environment (AFCEE) (with concurrence from the U.S. Environmental Protection Agency and the MassDEP) turned off the original CS-4 treatment system in May 2003 because of its ineffectiveness (AFCEE 2008a). A new CS-4 remedial system, which consists of three extraction wells (Figures B-1, B-2, and B-3), began operation in November 2005 as part of the Southwest Plumes remedial system (AFCEE 2004, 2008b).

The Southwest Plumes remedial system was designed to collectively remediate the CS-4, CS-20, CS-21, and Fuel Spill-29 (FS-29) groundwater plumes (Figure B-1). The contaminated groundwater is captured by extraction wells in each plume and treated in a centrally located treatment plant, the Hunter Avenue Treatment Facility (HATF). The flow from the CS-4 and CS-20 extraction wells is combined, enters the HATF through a common influent line, and is treated through a series of granular activated carbon vessels. Likewise, the flow from the CS-21 (and formerly from the FS-29 extraction wells when the FS-29 wells were operational prior to September 2010) enters the HATF through a common influent line; this water is treated through a second granular activated carbon treatment train. The treated water from the CS-4/CS-20 and CS-21/FS-29 treatment trains exits the HATF in a combined effluent line and all treated water is returned to the aquifer through reinjection wells, an infiltration trench, and an infiltration gallery (AFCEE 2011b).

The CS-4 system began operation in November 2005 at a design flow rate of 620 gpm. CS-4 extraction well 02EW0016 was turned off on 09 December 2009 (with regulatory concurrence) because it was no longer contributing to capture and cleanup of the CS-4 plume (AFCEE 2011a). As of December 2010, the CS-4 remedial system was operating at a flow rate of 170 gpm, with 85 gpm being pumped from each operating extraction well (AFCEE 2012a).

The most recent groundwater transport modeling results predict that the two remaining CS-4 extraction wells (02EW0014 and 02EW0015) can be shut down in approximately 2016. After system shutdown in 2016, it is anticipated that the CS-4 plume will be considered stable since the remaining contamination is anticipated to be located only in low hydraulic conductivity portions of the aquifer and is not predicted (by the groundwater model) to advance any farther. The transport simulations predict that the PCE within those low hydraulic conductivity portions of the aquifer will decrease to concentrations below the MCL through natural attenuation by approximately 2030 (AFCEE 2011a).

B1.2 STEP 1: CLEAN WATER LENS

As established in Section 4.1.1 and depicted graphically in Figure 4-1 of the main document, the first step in evaluating the possibility of VI for a groundwater plume is determining whether a continuous 3-ft-thick clean water lens is present above the entire plume and is expected to remain for the foreseeable future as long as the plume exists. If so, it can be concluded that the VI pathway is incomplete and no further evaluation is required.

The clean water lens evaluation included a review of the analytical data for the four CS-4 COCs (PCE, TCE, 1,1,2,2-TeCA, and EDB), as well as other plume-related volatile organic compounds (VOCs) included in the list of VI contaminants of potential concern in Table 4-1 of the main document. For this CS-4 VI evaluation, the absence of plume-related VOC detections in groundwater in the portion of the aquifer above the plume footprint will define the presence of clean water. The locations of all the monitoring points used for this VI evaluation are shown on Figure B-3. The most recent PCE data are used to support this evaluation and are shown on the north-south cross-sectional depiction of the CS-4 plume on Figure B-4, and the analytical data are summarized in Table B-1. The well construction and sampling location information used in this evaluation are included in Table B-2.

As described in the conceptual site model (CSM) in Section B1.1, the most recent monitoring data indicate that the CS-4 plume is located deep in the aquifer. In addition, historic characterization data collected during the RI (AFCEE 1999) and the pre-remedial system design investigation (AFCEE 2003), as well as recent data collected under the System Performance and

Ecological Impact Monitoring (SPEIM) program, confirms that the CS-4 plume is overlain by a substantial thickness of clean water well in excess of 3 ft. The data that support this aspect of the CSM are as follows and are presented on Figure B-3, Figure B-4, and in Table B-1:

- Groundwater vertical profile data collected during a 2010 optimization evaluation at direct push drilling locations 02DP0001 and 02DP0002 located near the operating extraction wells indicate the presence of over 100 ft of clean water above the CS-4 plume.
- Monitoring data collected at the following wells screened above the CS-4 plume, in order of most recent to oldest, were used to confirm the presence of a clean water lens: 02MW1213 (2009), 69MW1268A (2009), 02OW0010B (2009), 02OW0016C (2002), 02OW0014B (2001), 02OW0015A/B (2001), 02OW0016B (2001), 02PZ0013B (2001), and O2OW0009A (1998).
- Groundwater vertical profile data collected at sample elevations above the CS-4 plume during rotosonic drilling at 02MW1258A, 02MW1259A, and 02MW2000A in 2001/2002 indicates the presence of at least a 40 ft thickness of clean water above the plume at that time. It is noted that 02MW1258A is now located outside of the plume footprint to the north; however, when installed in 2001, the trailing edge of the CS-4 plume was present in this area and the data support the overall concept of a clean water lens above the plume.
- Monitoring data collected at the following wells screened above the CS-4 plume, in order of most recent to oldest, were used to confirm the presence of a clean water lens: 02MW1213 (2009), 69MW1268A (2009), 02OW0010B (2009), 02OW0016C (2002), 02OW0014B (2001), 02OW0015A/B (2001), 02OW0016B (2001), 02PZ0013B (2001), and O2OW0009A (1998).

In summary, characterization and monitoring data from multiple locations throughout the area of the CS-4 plume confirm the presence of a clean water lens overlying the entire plume well in excess of the 3-ft thickness criterion used for this VI screening evaluation. It is acknowledged, however, that some of these characterization data are not recent (i.e., dating back to 1998 in some cases). But when combined with more recent data collected in 2009/2010 and the overall understanding of the hydrogeologic aspect of the CSM, they still provide sound lines of evidence that the CS-4 plume is located deep in the aquifer and is overlain by a substantial thickness of clean water. Furthermore, given the substantial thickness of clean water above the whole plume, and the plume being captured by the remedial system, a change in the clean water lens presence is not anticipated in the future.

B2.0 CONCLUSIONS AND RECOMMENDATIONS

B2.1 CONCLUSIONS

A review of groundwater characterization and monitoring data collected at CS-4 indicates that a continuous clean water lens at least 3 ft thick is present above the entire body of the CS-4 plume and is expected to be present in the future as long as the plume exists. As evidenced by data indicating the presence of this substantial clean water lens and the ongoing active treatment to control its migration, the VI exposure pathway at CS-4 is incomplete, and further evaluation of VI associated with the CS-4 plume is not necessary.

B2.2 RECOMMENDATIONS

No further monitoring or data collection is needed specific to VI. However, as part of the ongoing remedial actions at CS-4, AFCEE will continue to monitor the nature and extent of the CS-4 plume under the SPEIM program and will re-evaluate the VI exposure pathway if conditions change such that VI could become a concern.

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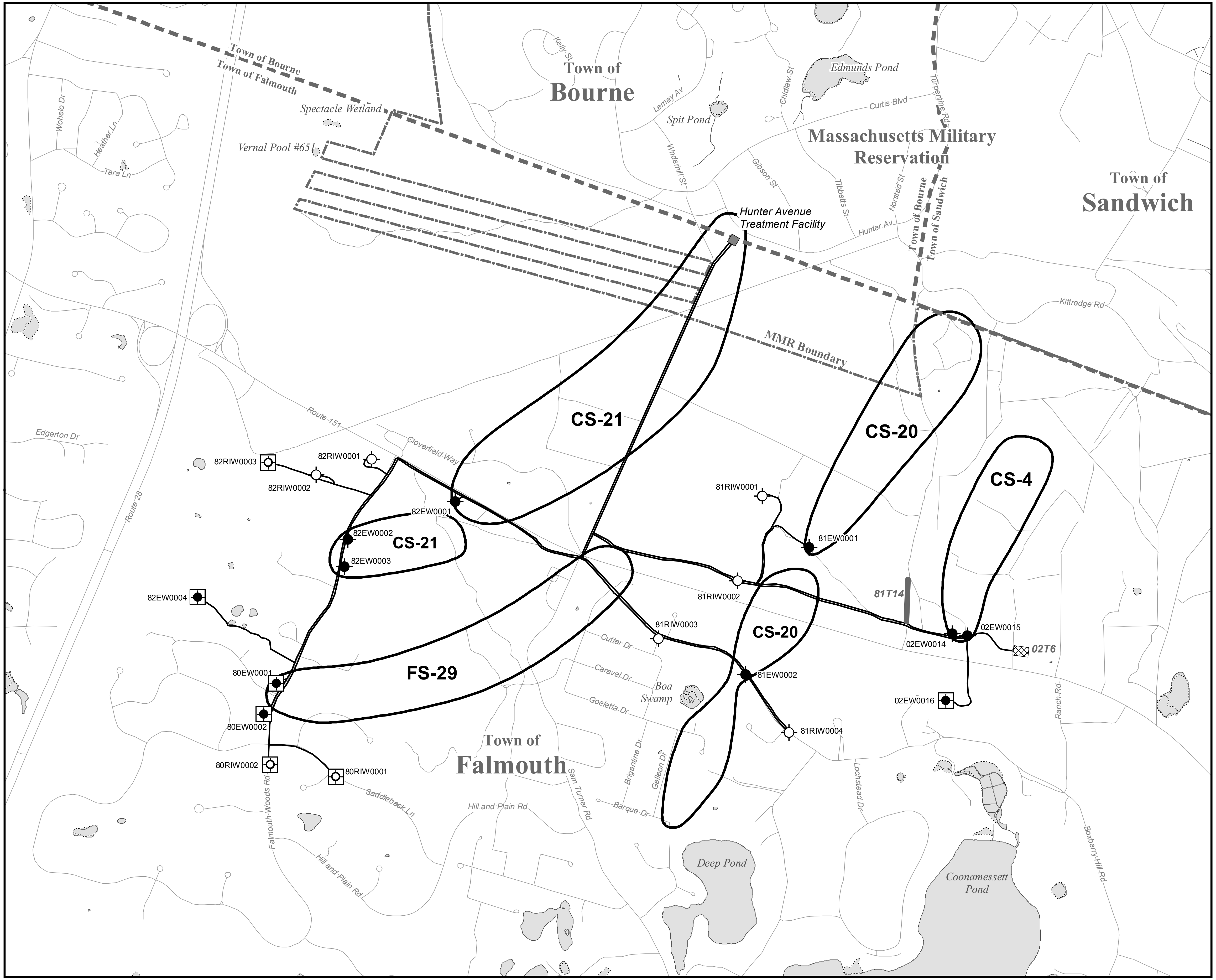


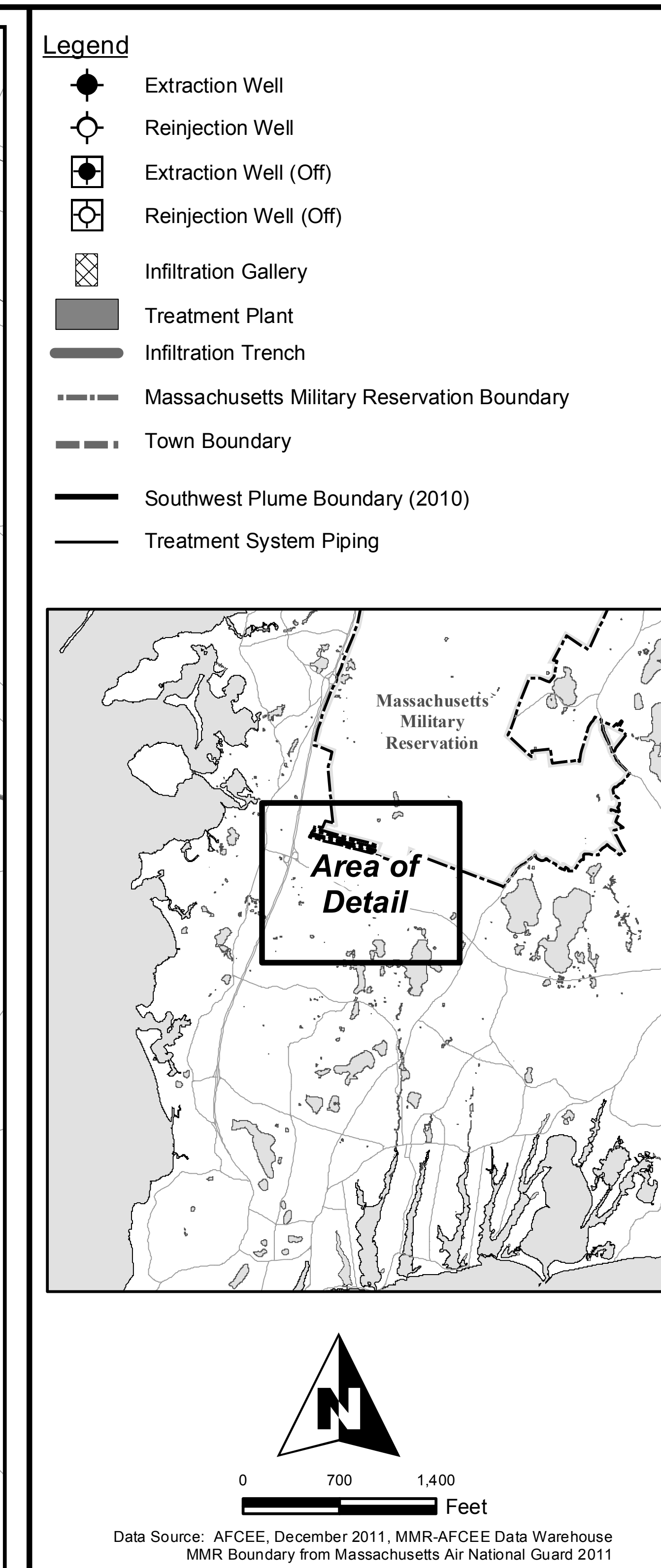


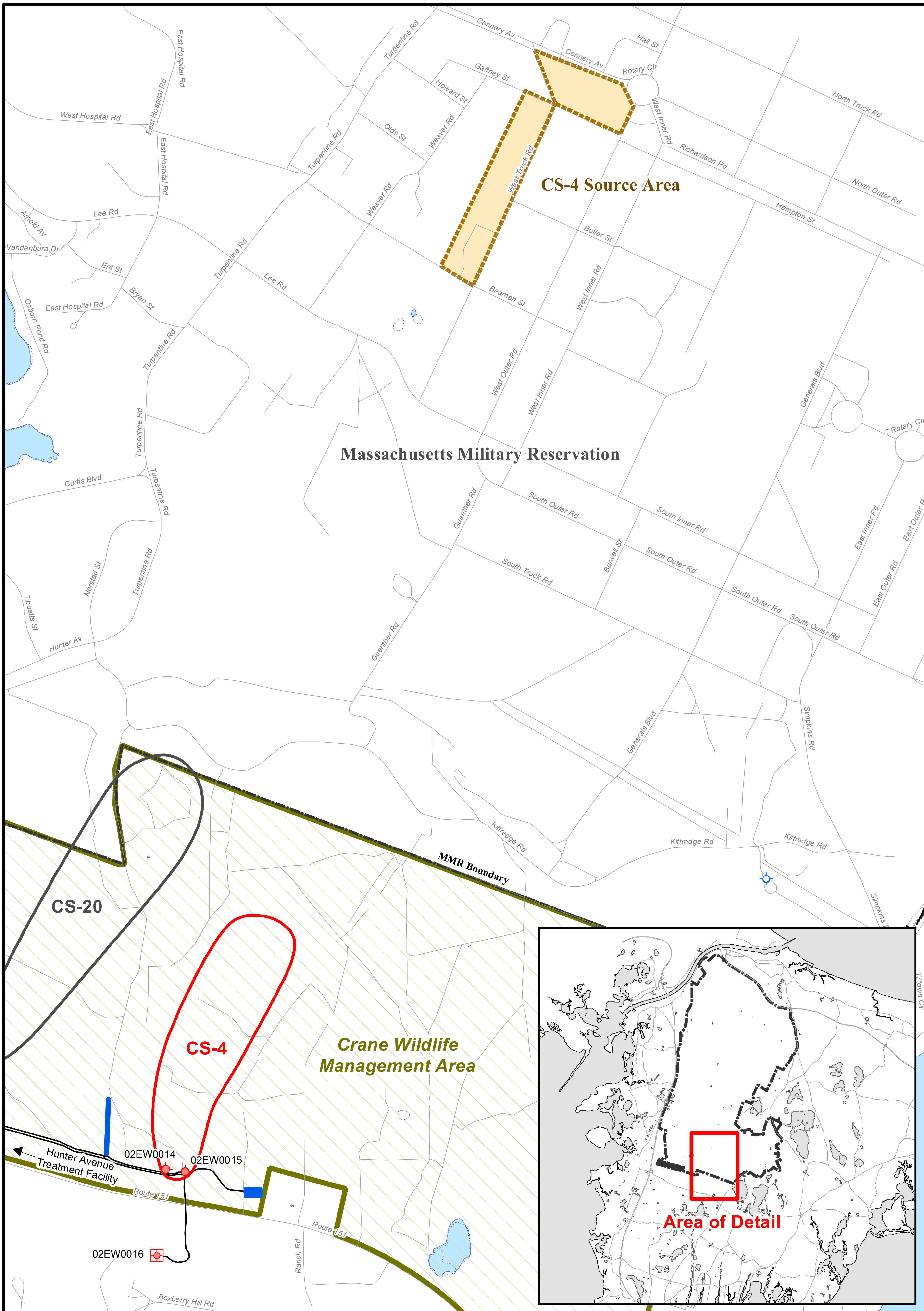
FIGURE B-1

SOUTHWEST PLUMES REMEDIAL SYSTEM AND HUNTER AVENUE TREATMENT FACILITY

AFCEE - Massachusetts Military Reservation

Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

CH2MHILL.



Legend

- CS-4 Plume Boundary
- Other Southwest Plume Boundary
- Massachusetts Military Reservation Boundary
- Infiltration Trench/Gallery
- Treatment System Pipeline
- Extraction Well (On)
- Extraction Well (Off)
- Crane Wildlife Area

Data Source: AFCEE, October 2011, MMR-AFCEE Data Warehouse
MMR Boundary from MA ARNG 2011

N

0 540 1,080 Feet

FIGURE B-2

CS-4 SOURCE AREA, GROUNDWATER PLUME, AND REMEDIAL SYSTEM LAYOUT

AFCEE - Massachusetts Military Reservation

Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

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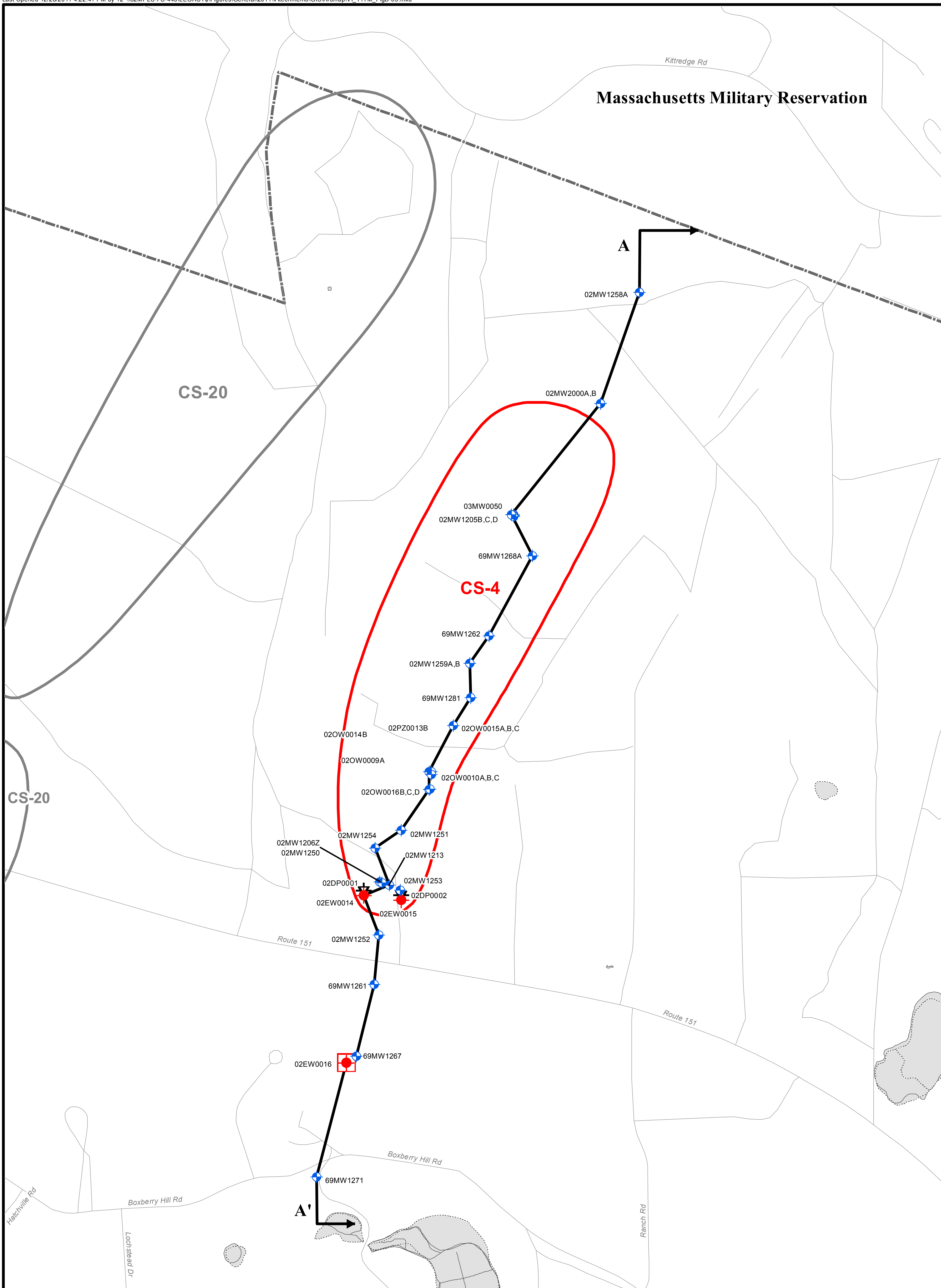

Legend

- Massachusetts Military Reservation Boundary
- 2010 CS-4 Plume Boundary
- Other Southwest Plume Boundary
- Bog/Wetland
- Extraction Well (On)
- Extraction Well (Off)
- Monitoring Well
- Direct Push Location
- Piezometer

Note: The plan view Southwest Plume boundaries will be updated following the 2012 triennial sampling event.

Data Source: AFCEE, October 2011, MMR-AFCEE Data Warehouse
MMR Boundary from MA ARNG 2011

N

0 270 540 Feet

FIGURE B-3

CS-4 GROUNDWATER PLUME AND LOCATION OF CROSS-SECTION LINE

AFCEE - Massachusetts Military Reservation

Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

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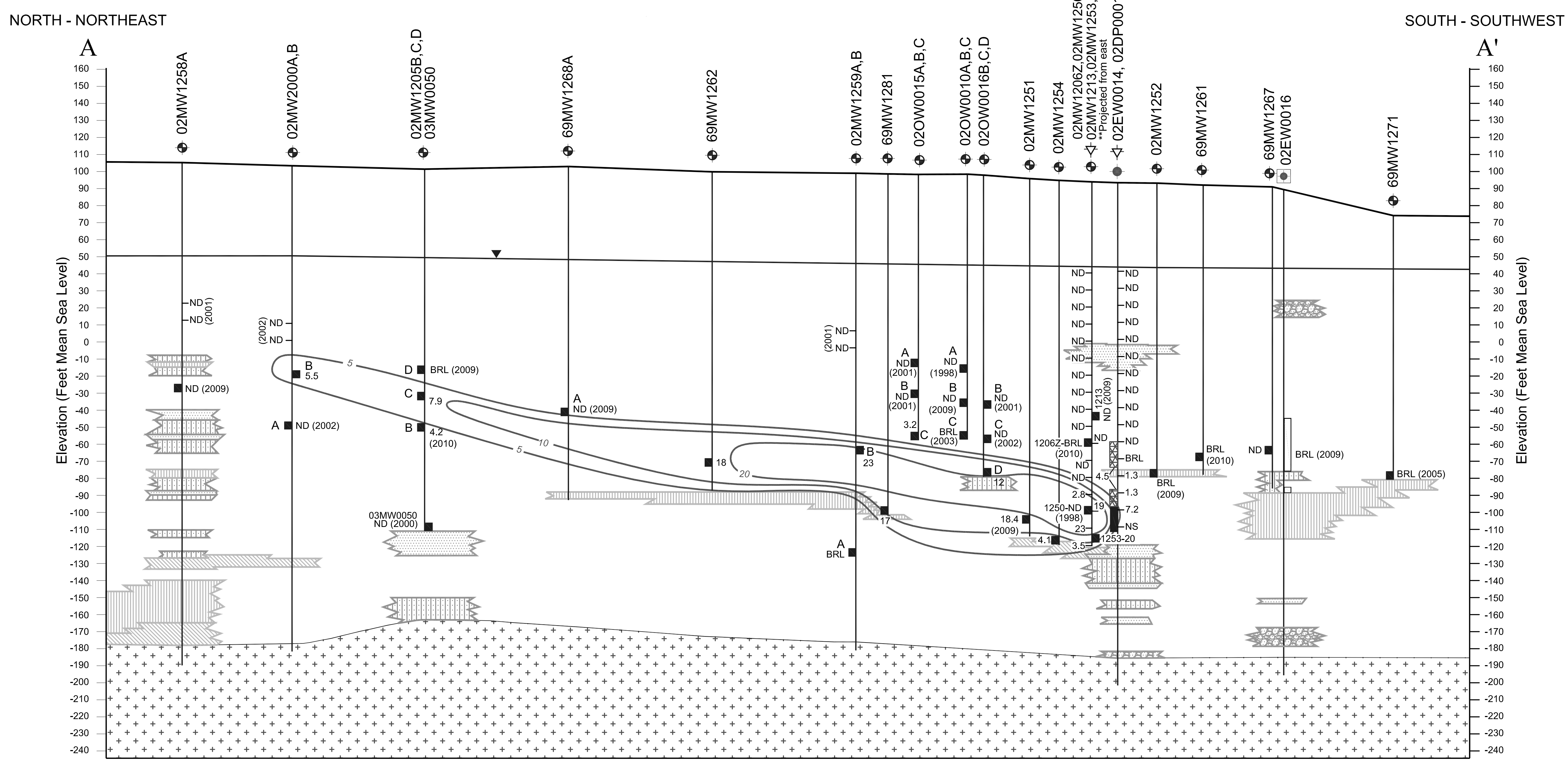

Legend

- Monitoring Well
- Extraction Well (On)
- Extraction Well (Off)
- Screen Closed (Packered)
- BRL Below Reporting Limit
- ND Nondetect
- NS Not Sampled
- Water Table (05/19/2010 - 05/21/2010)
- 7.9 PCE Data (µg/L) Collected in 2011 Unless Otherwise Noted
- Direct Push Location
- A Well Screen ID
- 5 PCE Isoconcentration Contour (MCL = 5 µg/L) (Dashed Where Inferred)
- 1.3 PCE Vertical Profile Data (µg/L) (January - February 2010 Unless Otherwise Noted)
- Clay
- Silt
- Silty Sand
- Fine Sand
- Gravelly Sand
- Bedrock

Data Source: AFCEE, October 2011, MMR-AFCEE Data Warehouse.

Notes:
1) This cross-section presents the most recent (2011 unless otherwise noted) data for CS-4, but does not correspond to the 2010 plume boundary presented on Figure B-3. The plan view Southwest Plume boundaries will be updated following the 2012 triennial sampling event.
2) Vertical profile data collected prior to 2010 from the shallowest intervals are shown to support VI clean water lens evaluation.

V: 60
H: 600
0 Feet

FIGURE B-4

CS-4 CROSS-SECTION A - A'

AFCEE - Massachusetts Military Reservation

Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

CH2MHILL

Table B-1
CS-4 Groundwater Data Used in Support of VI Evaluation
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Location	Date Sampled	Mid-Sample Elevation (ft msl)	Sampling Method[1]	Result[2]
02DP0001	2/2/2010	40.5	VP	No detections of plume-related VI COPCs
02DP0001	2/3/2010	30.5	VP	No detections of plume-related VI COPCs
02DP0001	2/3/2010	20.5	VP	No detections of plume-related VI COPCs
02DP0001	2/3/2010	10.5	VP	No detections of plume-related VI COPCs
02DP0001	2/2/2010	0.5	VP	No detections of plume-related VI COPCs
02DP0001	2/3/2010	-9.5	VP	No detections of plume-related VI COPCs
02DP0001	2/4/2010	-19.5	VP	No detections of plume-related VI COPCs
02DP0001	2/4/2010	-29.5	VP	No detections of plume-related VI COPCs
02DP0001	2/4/2010	-39.5	VP	No detections of plume-related VI COPCs
02DP0001	2/5/2010	-49.5	VP	No detections of plume-related VI COPCs
02DP0001	2/5/2010	-59.5	VP	No detections of plume-related VI COPCs
02DP0002	1/20/2010	40.5	VP	No detections of plume-related VI COPCs
02DP0002	1/20/2010	30.5	VP	No detections of plume-related VI COPCs
02DP0002	1/20/2010	20.5	VP	No detections of plume-related VI COPCs
02DP0002	1/21/2010	10.5	VP	No detections of plume-related VI COPCs
02DP0002	1/21/2010	0.5	VP	No detections of plume-related VI COPCs
02DP0002	1/21/2010	-9.5	VP	No detections of plume-related VI COPCs
02DP0002	1/21/2010	-19.5	VP	No detections of plume-related VI COPCs
02DP0002	1/21/2010	-29.5	VP	No detections of plume-related VI COPCs
02DP0002	1/21/2010	-39.5	VP	No detections of plume-related VI COPCs
02DP0002	1/22/2010	-49.5	VP	No detections of plume-related VI COPCs
02DP0002	1/22/2010	-59.5	VP	No detections of plume-related VI COPCs
02DP0002	1/26/2010	-69.5	VP	No detections of plume-related VI COPCs
02DP0002	1/26/2010	-79.5	VP	No detections of plume-related VI COPCs
02MW1213	5/21/2009	-43.52	MW	No detections of plume-related VI COPCs
02MW1258A	2/11/2001	22.75	VP	No detections of plume-related VI COPCs
02MW1258A	2/11/2001	12.75	VP	No detections of plume-related VI COPCs
02MW1259A	2/20/2001	6.53	VP	No detections of plume-related VI COPCs
02MW1259A	2/20/2001	-3.47	VP	No detections of plume-related VI COPCs
02MW2000A	3/8/2002	0.91	VP	No detections of plume-related VI COPCs
02MW2000A	3/7/2002	10.91	VP	No detections of plume-related VI COPCs
02OW0009A	5/26/1998	-13.84	MW	No detections of plume-related VI COPCs
02OW0010B	5/14/2009	-35.64	MW	No detections of plume-related VI COPCs
02OW0014B	12/17/2001	-35.42	MW	No detections of plume-related VI COPCs
02OW0015A	5/15/2001	-12.34	MW	No detections of plume-related VI COPCs
02OW0015B	5/15/2001	-30.37	MW	No detections of plume-related VI COPCs
02OW0016B	5/18/2001	-36.7	MW	No detections of plume-related VI COPCs
02OW0016C	7/9/2002	-56.8	MW	No detections of plume-related VI COPCs
02PZ0013B	12/17/2001	-36.91	MW	No detections of plume-related VI COPCs
69MW1268A	5/19/2009	-41.01	MW	No detections of plume-related VI COPCs

Data Source: AFCEE, December 2011, MMR-AFCEE Data Warehouse

Notes:

1. Sample collection method:
   VP = vertical profile groundwater sampling (direct push, rotosonic, or screened hollow-stem auger drilling methods)
   MW = fixed monitoring well

2. See Table 4-1 of the main document for a complete list of VI COPCs.

The data summarized in this table specifically support the CS-4 clean water lens VI evaluation and typically include the most recent sampling results for each location for the plume-related VI COPCs only. If additional historic sampling data exist, they are available for review in the AFCEE-MMR Data Warehouse.

Vertical profile data presented only included the relevant sample intervals used to support this CS-4 VI evaluation; if analytical data from deeper sample intervals exist, they are available in the AFCEE MMR Data Warehouse.

Key:

COPC = contaminant of potential concern
CS-4 = Chemical Spill-4
ft msl = feet mean sea level
VI = vapor intrusion

Table B-2
CS-4 Well Construction and Sample Location Information
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Location	Northing (ft)	Easting (ft)	Surface Elevation (ft msl)	Measuring Point Elevation (ft msl)	Total Well Depth (ft bgs)	Top Screen Depth (ft bgs)	Bottom Screen Depth (ft bgs)	Top Screen Elevation (ft msl)	Bottom Screen Elevation (ft msl)	Screen Length (ft)
02DP0001	232100	855093	93	-	-	NA	NA	NA	NA	NA
02DP0002	232074	855297	93	-	-	NA	NA	NA	NA	NA
02MW1213	232136	855233	94	96.97	140	135.00	140.00	-41.02	-46.02	5
02MW1258A	235379	856600	105	104.85	135	129.75	134.65	-24.50	-29.40	5
02MW1259A	233350	855674	99	98.71	226	220.00	225.00	-120.97	-125.97	5
02MW2000A	234770	856387	103	103.04	155	150.03	154.72	-46.62	-51.31	5
02OW0009A	232842	855249	100	98.82	116	111.00	116.00	-11.34	-16.34	5
02OW0010A	232756	855449	98	100.55	116	111.00	116.00	-13.06	-18.06	5
02OW0014B	232967	855159	100	99.92	138	133.00	138.00	-32.92	-37.92	5
02OW0015A	233030	855587	101	101.05	116	111.00	116.00	-9.84	-14.84	5
02OW0015B	233020	855585	101	100.96	134	129.00	134.00	-27.87	-32.87	5
02OW0016B	232648	855445	98	99.66	137	131.70	136.70	-34.20	-39.20	5
02OW0016C	232661	855450	98	99.43	157	152.00	157.00	-54.30	-59.30	5
02PZ0013B	232943	855245	97	96.67	136	131.30	136.30	-34.41	-39.41	5
69MW1268A	233937	856016	100	99.83	144	138.77	143.77	-38.51	-43.51	5

Data Source: AFCEE, December 2011, MMR-AFCEE Data Warehouse

Key:
bgs = below ground surface
CS-4 = Chemical Spill-4
ft = feet
msl = mean sea level
NA = data not available; locations are direct push vertical profile locations and have no screen information.

APPENDIX C

CS-10 Vapor Intrusion Evaluation

TABLE OF CONTENTS

Figures

TABLE OF CONTENTS

Tables

ACRONYMS AND ABBREVIATIONS

AFCEE	Air Force Center for Engineering and the Environment
ARNG	Army National Guard
bgs	below ground surface
BOMARC	Boeing Michigan Aerospace Research Center
COC	contaminant of concern
COPC	contaminant of potential concern
CS-10	Chemical Spill-10
ETI	extraction, treatment, and infiltration
ETR	extraction, treatment, and reinjection
FS-24	Fuel Spill-24
ft	foot/feet
GAC	granular activated carbon
gpm	gallons per minute
IP	In-Plume
MCL	Maximum Contaminant Level
MMR	Massachusetts Military Reservation
msl	mean sea level
NCL	north central lobe
NL	northern lobe
PCE	tetrachloroethene
RI	Remedial Investigation

ACRONYMS AND ABBREVIATIONS

ROD	Record of Decision
SL	Southern Lobe
SPEIM	System Performance and Ecological Impact Monitoring
SRTF	Sandwich Road Treatment Facility
TCE	trichloroethene
USAF	U.S. Air Force
UTES	Unit Training Equipment Site
VI	vapor intrusion
VOC	volatile organic compound
µg/L	micrograms per liter

C1.0 CHEMICAL SPILL-10 VAPOR INTRUSION DATA EVALUATION

C1.1 CS-10 CONCEPTUAL SITE MODEL

The Chemical Spill-10 (CS-10) groundwater plume is a dissolved-phase groundwater plume located at the southeast corner of the Massachusetts Military Reservation (MMR) that extends off-base into the towns of Falmouth and Mashpee (Figure 1-2 of main document). Though the primary sources of the CS-10 plume are spills and releases that occurred during the operation of the former Boeing Michigan Aerospace Research Center (BOMARC) (from 1960 to 1973) and the Unit Training Equipment Site (UTES) (in operation since 1978), additional sources of contamination are presumed to have contributed to the CS-10 plume, based on the observed contaminant distribution in groundwater.

The contaminants of concern (COCs) for the CS-10 plume are trichloroethene (TCE) and tetrachloroethene (PCE). The plume is defined as the extent of groundwater containing TCE and PCE at concentrations exceeding the Maximum Contaminant Level (MCL) of 5 micrograms per liter (µg/L) for each compound. In 2011, the maximum concentrations of TCE and PCE detected in the CS-10 plume monitoring network were 3,010 µg/L, and 85 µg/L, respectively; however, TCE concentrations approaching 4,000 µg/L were detected during recent data gap investigation activities during drilling (AFCEE 2012a).

For the purposes of this vapor intrusion (VI) evaluation, the CS-10 plume is divided into three areas that are discussed individually: 1) the In-Plume (IP) Area, 2) the Leading Edge and Sandwich Road Lobes, and 3) the Southern Trench Area. The leading edge (part of the second area) is composed of three lobes: the northern lobe (NL); north central lobe (NCL); and southern lobe (SL) (Figure C-1).

The main source area for the CS-10 groundwater plume is referred to as CS-10/Fuel Spill-24 (FS-24). The CS-10/FS-24 source area occupies approximately 38 acres at the eastern boundary of the MMR to the west of Snake and Weeks Ponds (Figure C-1). Originally, the CS-10/FS-24 source area consisted of a number of buildings constructed as part of the BOMARC site by the U.S. Air Force (USAF), which maintained approximately 56 BOMARC ground-to-air missile

launcher systems in a state of operational readiness between 1960 and 1973. Cleaning solvents and fuels were used at the CS-10/FS-24 source area for maintenance operations and BOMARC power and heat. The USAF abandoned the BOMARC facility in 1973 (AFCEE 2008a). In 1978, the Massachusetts Army National Guard (ARNG) incorporated the abandoned missile facility into Camp Edwards and began limited use of the abandoned buildings for equipment maintenance and storage. Since 1978, the site has been used by ARNG as the UTES facility for maintenance and storage of vehicles. Motor oil, hydraulic fluid, battery electrolyte, PCE, PD-680 Safety Clean, paints, and paint removers have been used on site. Shelters utilized by the missile launcher systems and a subsurface utility corridor connecting the shelters (utilidor system) were removed from the site in 2005 (AFCEE 2008a).

In 1985, an investigation of the possible impact of UTES/BOMARC activities on local groundwater quality detected several chlorinated volatile organic compounds (VOCs) in the groundwater (AEHA 1988). Subsequently, a site investigation and an interim Remedial Investigation (RI) were conducted to investigate suspected sources of groundwater contamination, evaluate the extent of groundwater contamination, and determine the significance of facility storm sewers as contaminant migration pathways (ABB-ES 1992). RIs were conducted separately for the CS-10/ FS-24 source area (CDM 1997) and the groundwater plume (CDM 1996), and numerous data gap investigations were conducted in support of remedial actions. During leading edge investigations in 1997, it was determined that the CS-10 plume had migrated beneath and beyond Ashumet Pond, and the leading edge NCL, NL, and SL were initially studied and delineated in an RI (AFCEE 2001).

Based on the most recent depiction of the CS-10 plume boundary (AFCEE 2012a), the main body of the CS-10 plume (which is mainly on base and includes the Sandwich Road Lobe, IP area, and Southern Trench area) is approximately 2.7 miles long and 0.9 mile wide (Figure C-1). The most upgradient portion of the CS-10 Leading Edge NL is located approximately 500 feet (ft) downgradient of the MMR base boundary, and is approximately 3,800 ft long and up to 660 ft wide. The NL extends beneath Ashumet Pond to an isthmus between Ashumet and Johns Ponds (where it is captured by an extraction well). The Leading Edge NCL is approximately 3,300 ft long and up to 640 ft wide and is situated beneath Ashumet Pond and extends to the western shore of Johns Ponds. The Leading Edge SL is approximately

1,600 ft long and up to 400 ft wide and is beneath the southern edge of Ashumet Pond and an area south of Ashumet Pond. The total footprint of the CS-10 plume occupies approximately 1,066 acres (AFCEE 2010).

A plan view of the IP area with the location of the cross-section lines and the monitoring locations used to support this VI evaluation is shown on Figure C-2; Figures C-3 through C-5 present cross-sectional views of the IP area. Figures C-6 through C-9 and Figures C-10 through C-11 present similar information for the Leading Edge and Sandwich Road Lobes, and Southern Trench area, respectively.

The topography of the land above the CS-10 plume is characterized as a broad, flat, and gently southward sloping glacial outwash plain referred to as the Mashpee Pitted Plain. Within the footprint of the plume, the maximum and minimum ground surface elevations are 142 ft mean sea level (msl) and 38 ft msl, respectively (AFCEE 2010). Characteristic of many of the MMR groundwater plumes, the CS-10 plume descended in the aquifer as it migrated from source areas due to recharge accretion, which has resulted in the majority of the plume being located relatively deep in the aquifer and overlain by a lens of clean groundwater.

Flow within the aquifer is predominantly horizontal, and in the CS-10 area generally flows in a southerly direction north of Ashumet Pond shifting to a southeasterly direction beneath Ashumet and Johns ponds (Figure C-1). The depth to groundwater in the vicinity of the CS-10 plume ranges from approximately 85 ft below ground surface (bgs) below the northern part of the plume near the CS-10/FS-24 source area to less than a few ft bgs near Ashumet and Johns Ponds. The elevation of the water table within the CS-10 area ranges from approximately 65 ft msl in the north to 40 ft msl in between Ashumet and Johns ponds to the south; it is noted that these surface water bodies are glacial kettle ponds and the surface water elevation is synonymous with the groundwater elevation around the pond. The aquifer saturated thickness in the CS-10 area ranges from approximately 230 to 320 ft (AFCEE 2010).

From 1996 through 2005, several source area cleanup actions were conducted at BOMARC/UTES, including underground storage tank removal, drainage structure removal, removal of approximately 1,500 tons of contaminated soil, and the installation and operation of a

soil vapor extraction system. This system operated from 2002 through 2005 removing approximately 5 pounds of VOCs from the soil. These removal actions resulted in a no further action decision for the primary CS-10 source area (i.e., CS-10/FS-24) although institutional controls are required (AFCEE 2008a).

The Department of Defense and the U.S. Environmental Protection Agency, with concurrence from the Massachusetts Department of Environmental Protection, implemented an interim action for the CS-10 groundwater plume and six other MMR plumes under an Interim Record of Decision (ROD). The selected interim remedy consisted of groundwater extraction at the leading edge of the plume, groundwater treatment via granular activate carbon (GAC), discharge of treated water to groundwater (and/or other beneficial use), and institutional controls (ANG 1995).

Three systems were designed to remediate the CS-10 plume: (1) the CS-10 Sandwich Road extraction, treatment, and reinjection (ETR) system which consists of eight closely-spaced extraction wells for the Sandwich Road lobe, a Southern Trench extraction well (added in 2009), four GAC treatment trains within the Sandwich Road Treatment Facility (SRTF), and six reinjection wells; (2) the CS-10 IP extraction, treatment, and infiltration (ETI) system which consists of nine extraction wells located within the body of the plume, four GAC treatment trains within four treatment plant buildings, two infiltration trenches, and a reinjection well (added in 2009); and (3) the CS-10 NL extraction well which utilizes the SRTF and the Storm Drain-5 North reinjection wells. The CS-10 plume and treatment system components are presented in Figure C-1. Collectively, the total rate of treatment by the three CS-10 remedial systems is 3,115 gallons per minute (gpm) (AFCEE 2012a). Further details on CS-10 remedial system operation and performance are included in the *2011 Operations and Maintenance Plan for Groundwater Extraction and Treatment Systems and Wind Turbine* (AFCEE 2011) and the *Chemical Spill-10 2011 Summary Letter Report* (AFCEE 2012a).

In 2009, the Air Force Center for Engineering and the Environment (AFCEE) finalized the ROD for the CS-10 groundwater plume, which documents the selected remedy for CS-10 groundwater. The selected remedy includes continued operation of the CS-10 remedial systems installed under the Interim ROD (ANG 1995), installation of an additional extraction well (03EW2112) and

reinjection well (03RI2112) to address contamination in the Southern Trench area, and long-term monitoring for the NCL, SL, and an area located on the east side of Johns Pond (AFCEE 2009).

Using the December 2007 version of the TCE plume shell for the main body of the CS-10 plume, and assuming the remedial systems operate continuously at current pumping rates, groundwater transport modeling results indicate that by 2055 CS-10 IP and Sandwich Road extraction wells will no longer be contributing to plume cleanup and can be shut down. By 2055, the transport modeling indicates that one isolated area of contamination, located downgradient of IP extraction well 03EW2109, will remain in a silt layer and will attenuate in place to concentrations below the MCL by 2094 (AFCEE 2012a).

Using the April 2005 version of NL TCE plume shell and assuming the extraction well will operate continuously at 175 gpm which was a condition for the modeling simulation; groundwater transport modeling results indicate that by 2030 the NL extraction well can be shut down and only two small areas of contamination, located upgradient of the NL extraction well, remain in a silt layer. It’s important to note that the NL extraction well has been operating at a higher flow rate since September 2009 and is currently operating at 225 gpm. Using 2005 versions of the TCE plume shells for the NCL and the SL groundwater transport modeling results indicate that TCE concentrations in both these lobes will decrease below the MCL by 2025 through the processes of natural attenuation (AFCEE 2012a).

C1.2 STEP 1: CLEAN WATER LENS

As established in Section 4.0 and depicted graphically in Figure 4-1 of the main document, the first step in evaluating the possibility of VI for a groundwater plume is determining whether a continuous 3-ft-thick clean water lens is present above the entire plume and is expected to remain for the foreseeable future as long as the plume exists. If the evaluation indicates that a clean water lens is present using the criteria presented in Section 4.1.1 of the main document, it can be concluded that the VI pathway is incomplete and no further evaluation is required.

The clean water lens evaluation included a review of the analytical data for TCE and PCE, as well as other plume-related VI contaminants of potential concern (COPC) listed in Table 4-1 of the main document. The data used to support this clean water lens evaluation were collected during three primary site characterization efforts at CS-10. The clean water lens evaluation for the IP area relied on data collected between 2008 and 2012 during the IP area data gap investigation (technical memorandum in preparation). The data presented on the IP area cross-sections are generally the most recent data collected at monitoring wells or from recently installed borings where groundwater vertical profile sampling was conducted. Therefore, these cross-sections present the current distribution of contamination for the IP area. The Leading Edge Lobes and downgradient portion of the Sandwich Road Lobe were extensively characterized between 2003 and 2005 as documented in the *Final Chemical Spill-10 Leading Edge Technical Memorandum* (AFCEE 2005). The Southern Trench area was first characterized between 2005 and 2007 (AFCEE 2008b) and further data collection was completed in 2009 and 2011 to support an optimization evaluation of Southern Trench extraction well 03EW2112 (AFCEE 2012b). The clean water lens evaluation for the Leading Edge and Sandwich Road Lobes, and the Southern Trench Lobes, primarily rely on the characterization of the plume using data collected during the earlier investigations presented above. The cross-sectional depictions of the CS-10 plume presented on Figures C-7 through C-9 and C-11 represent the distribution of contamination based on these earlier investigations. Given the understanding of the site conceptual model, and considering the ongoing remedial actions and assessment of the performance monitoring data collected under the System Performance and Ecological Impact Monitoring (SPEIM) Program, these older data shown on the cross-sections are suitable for use in this VI evaluation.

For this CS-10 evaluation, the absence of plume-related VOC detections in groundwater in the portion of the aquifer above the plume footprint will define the presence of clean water. The above-referenced cross-sections (Figures C-3 through C-5, C-7 through C-9, and C-11) show data for TCE, the primary groundwater COC at CS-10. PCE data are omitted from the cross-sections (with one exception) because in general, TCE concentrations are higher than PCE concentrations and TCE is more spatially widespread than PCE. The analytical data supporting

the VI evaluation are summarized in Table C-1, and well construction and sampling location information is presented in Table C-2.

The following subsections evaluate clean water lens presence/absence in the IP area, the Leading Edge and Sandwich Road Lobes, and the Southern Trench area.

C1.2.1 In-Plume Area

The data that support the clean water lens evaluation for the IP area are as follows and are presented on Figures C-3, C-4, and C-5 and Table C-1:

- Groundwater vertical profile data collected from 03DP0031 in the source area in 2005 show detections of PCE in the four shallowest sample intervals (the top 30 to 40 ft below the water table) (Figure C-3). These PCE detections demonstrate that a clean water lens is not present throughout the CS-10/FS-24 source area.
- Further south along the western north-to-south IP area cross-section (Figure C-3), vertical profile data collected from 03MW1089A demonstrate the presence of a clean water lens that is at least 35 ft thick, and vertical profile locations south of 03MW1089A (between 03DP1108 and03MW1080A,B,C) indicate the presence of a clean water lens at least 60 ft thick (with the exception of one anomalous detection of TCE at a concentration below the reporting limit in the shallowest vertical profile sample at 03MW1074A). This low TCE detection was from a sampling interval approximately 15 ft below the water table. Based on no detections of VI COPCs at the water table in adjacent vertical profile borings 03DP1116 and 03DP1117, it is reasonable to conclude that a sufficiently thick clean water lens is present.
- Vertical profile data collected along the entire west-to-east cross-section through the IP area (Figure C-4), from 03DP1120 to 03DP2017, show that a clean water lens is present that is at least 50 ft thick.
- Vertical profile data along the entire eastern north-to-south cross-section through the IP area (Figure C-5), from 03DP1134 to 03DP1135, show that a clean water lens is present that is at least 90 ft thick.

C1.2.2 Leading Edge and Sandwich Road Lobes

The data that support the presence of a clean water lens in this area are as follows and are presented on Figures C-7, C-8, and C-9 and Table C-1:

- The northwest-to-southeast cross-section presented on Figure C-7 illustrates the distribution of contamination in the NL and an area east of Johns Pond formerly designated as the CS-10 Eastern Lobe based on data primarily collected through 2005. TCE concentrations in this

Eastern Lobe area have since declined to below the MCL, and therefore this lobe is no longer depicted as part of the CS-10 plume (Figure C-1). The vertical profile data shown on this cross-section between 03MW0201D and 00MW1011A,B demonstrate that a clean water lens at least 30 ft thick exists above the NL (and a clean water lens at least 170 ft thick exist above the former Eastern Lobe). Monitoring data from 00MW0584C also support the conclusion that a clean water lens in present above the area where the Eastern Lobe was previously depicted.

- The north-to-south cross-section shown on Figure C-7 depicts the SL, and vertical profile/monitoring well data from 00MW0589B,C and 00MW0606A indicate that a clean water lens at least 150 ft thick overlies the SL.
- The north-to-south cross-section shown on Figure C-8 illustrates the distribution of contamination associated with the NCL, and vertical profile data from the interval between 03DP0028 and 03MW2620A indicate that a clean water lens at least 60 ft thick is present above the NCL. Monitoring well data from 03MW2620B also support this conclusion.

C1.2.3 Southern Trench Area

The data that support the presence of a clean water lens for this area are as follows and are presented on Figure C-11 and Table C-1:

- Vertical profile and monitoring well data along the north to south cross-section presented on Figure C-11 show that a clean water lens at least 50 ft thick is present above the Southern Trench area portion of the CS-10 plume. Vertical profile data collected along the cross-section from 03MW1016A to 03MW1059A support this conclusion.

C1.2.4 Clean Water Lens Summary

Characterization and monitoring data from multiple locations throughout the CS-10 plume confirm the presence of a clean water lens overlying the majority of the plume well in excess of the 3-ft thickness criterion used for this VI screening evaluation. It is acknowledged, however, that some of these characterization data relied upon are not recent (i.e., dating back to 1996 in some cases). But when combined with more recent data and the overall understanding of the hydrogeologic aspect of the conceptual site model, the data still provide sound lines of evidence that the CS-10 plume is overlain by a sufficient thickness of clean water such that VI should not be a concern.

The only area without a clean water lens is a portion of the plume beneath source area CS-10/FS-24. This area requires additional evaluation (i.e., Step 2 of the VI evaluation process), as described below.

C1.3 STEP 2: BUILDINGS AND PREFERENTIAL AIRFLOW PATHWAYS

If it is determined that a constant 3-ft-thick lens of clean water does not exist or its presence cannot be demonstrated with an adequate level of certainty, the next step in a VI assessment is the evaluation of the proximity of potential receptors (Section 4.1.2 of main document). This is necessary for CS-10/FS-24 source area groundwater. Figure C-12 provides a summary of groundwater data collected at or near the water table in the CS-10/FS-24 source area. As shown on Figure C-12, detections of VI COPCs are present within 100 ft of Buildings 4601 and 4641. Thus, further VI evaluation (i.e., Step 3 of the VI evaluation process) is needed for the CS-10/FS-24 source area.

C1.4 STEP 3: COMPARE GROUNDWATER CONCENTRATIONS TO VI SCREENING VALUES

If a constant 3-ft-thick clean water lens cannot be identified with reasonable certainty or is not present, and an occupied building or preferential airflow pathway is, or could be, located within 100 ft of detections of any VI COPC, the third step in the VI assessment is the comparison of groundwater concentrations to the groundwater-to-indoor-air screening values presented in Table 4-1 of the main document. Section 4.1.3 of main text outlines this step in detail.

Figure C-12 and Table C-3 indicate that the detected concentrations of CS-10-related VI COPCs are all below VI screening values. Another component of Step 3 is to evaluate whether characterization data are adequate. The distribution of data shown on Figure C-12 suggests that the areal extent of contamination in this area has been adequately characterized such that it has been possible to draw conclusions relative to VI potential.

Another component of Step 3 is evaluating whether VI COPC concentrations in groundwater are increasing, stable, or decreasing. Long term monitoring data for this area show that VI COPC concentrations are either stable or decreasing.

The final component of Step 3 is to determine whether contaminant sources have been adequately controlled. As described above in Section C1.1, CS-10/FS-24 source area cleanup actions conducted from 2005 through 2007 resulted in a no further action decision for this area, and generally decreasing concentrations in the remainder of the CS-10 plume (AFCEE 2010) similarly attest to the adequacy of controlling the sources of the CS-10 plume. Thus, available information indicates that contaminant sources in the vicinity of CS-10 have been adequately controlled.

C2.0 CONCLUSIONS AND RECOMMENDATIONS

C2.1 CONCLUSIONS

A review of groundwater characterization and monitoring data collected at CS-10 indicates that a continuous clean water lens at least 3 ft thick is present above the entire CS-10 plume and is expected to be present in the future as long as the plume exists, with the exception of the CS-10/ FS-24 source area. Thus, for the majority of the CS-10 plume, the VI pathway is incomplete.

The one area without a clean water lens, the CS-10/FS-24 source area, has detections of VI COPCs in groundwater at or near the water table within 100 ft of buildings. However, these VI COPC concentrations are below VI screening levels. In addition, contaminant sources have been adequately controlled, the area has been sufficiently characterized, and contaminant concentrations are stable or decreasing. Thus, it is concluded that the VI pathway in this area is insignificant.

C2.2 RECOMMENDATIONS

No further monitoring or data collection is needed specific to VI. However, as part of the ongoing remedial actions at CS-10, AFCEE will continue to monitor the nature and extent of the CS-10 plume under the SPEIM program and will re-evaluate the VI exposure pathway if conditions change such that VI could become a concern.

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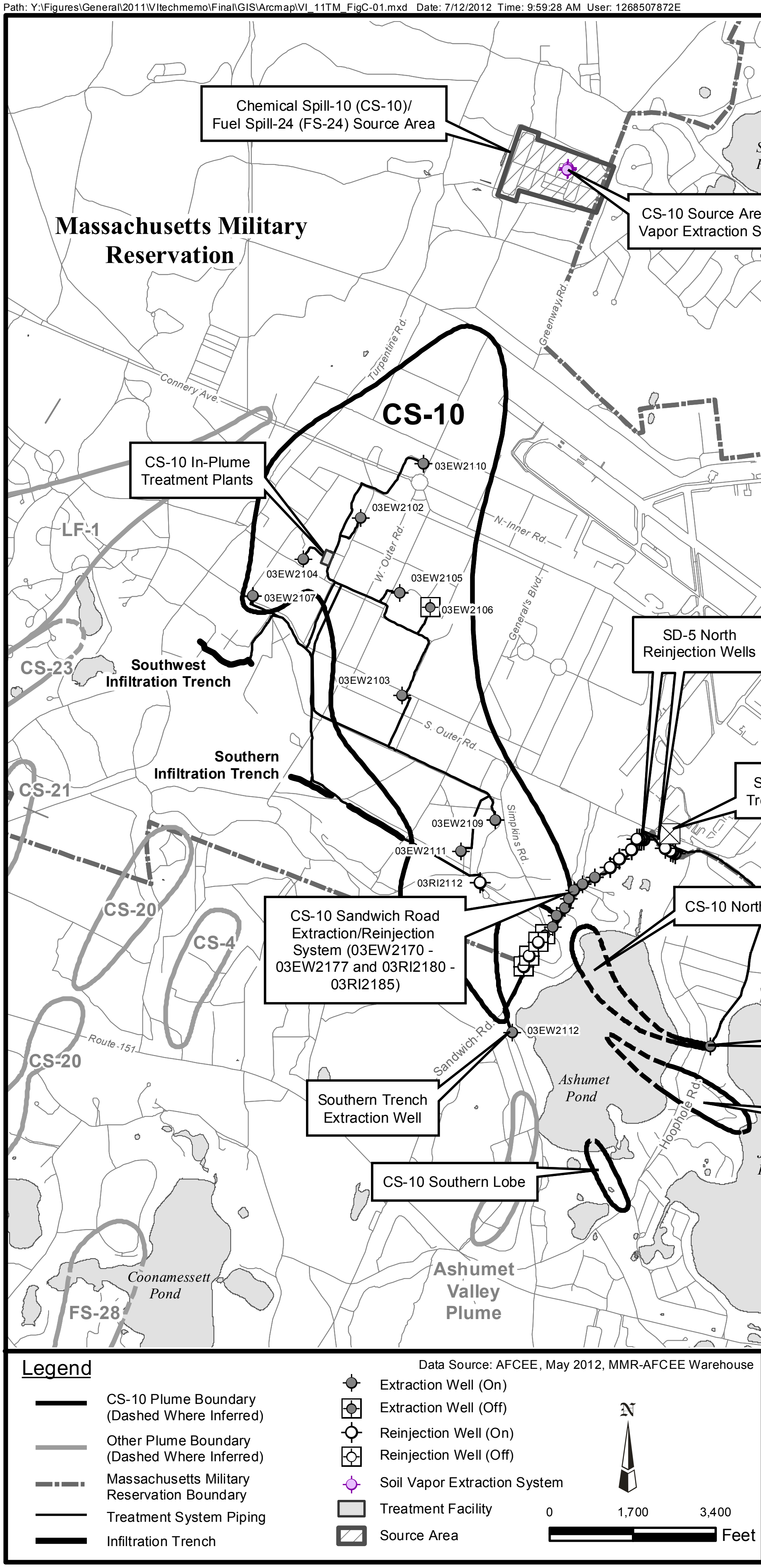

FIGURE C-1

CS-10 GROUNDWATER PLUME AND REMEDIAL SYSTEMS

AFCEE - Massachusetts Military Reservation

Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

CH2MHILL

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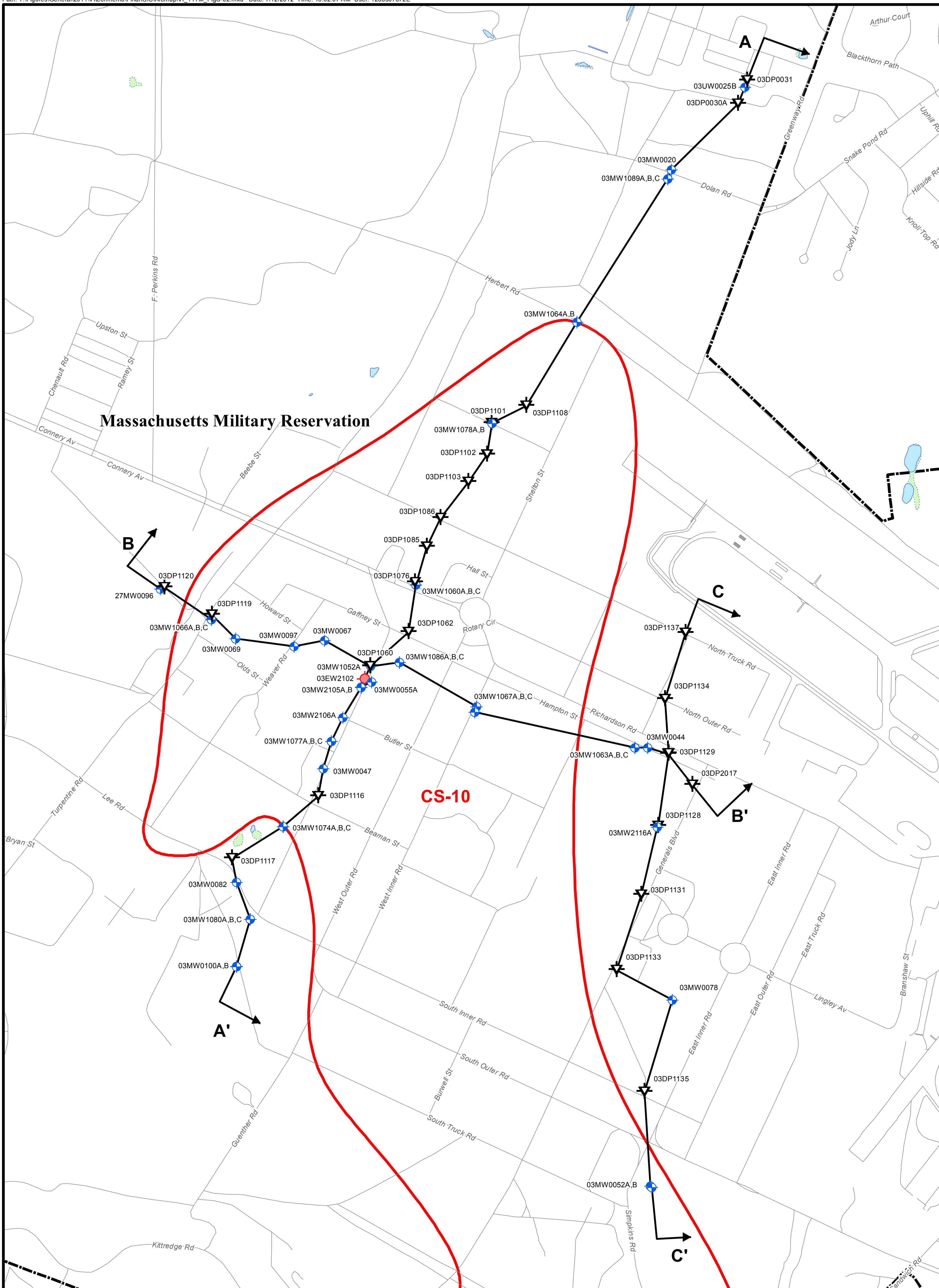


Legend

- Massachusetts Military Reservation Boundary
- Plume Boundary (Dashed Where Inferred)
- A A' Cross-Section Line
- Monitoring Well
- Extraction Well
- Direct Push Location

Data Source: AFCEE, June 2012, MMR-AFCEE Data Warehouse
MMR Boundary from Massachusetts Air National Guard 2011

N

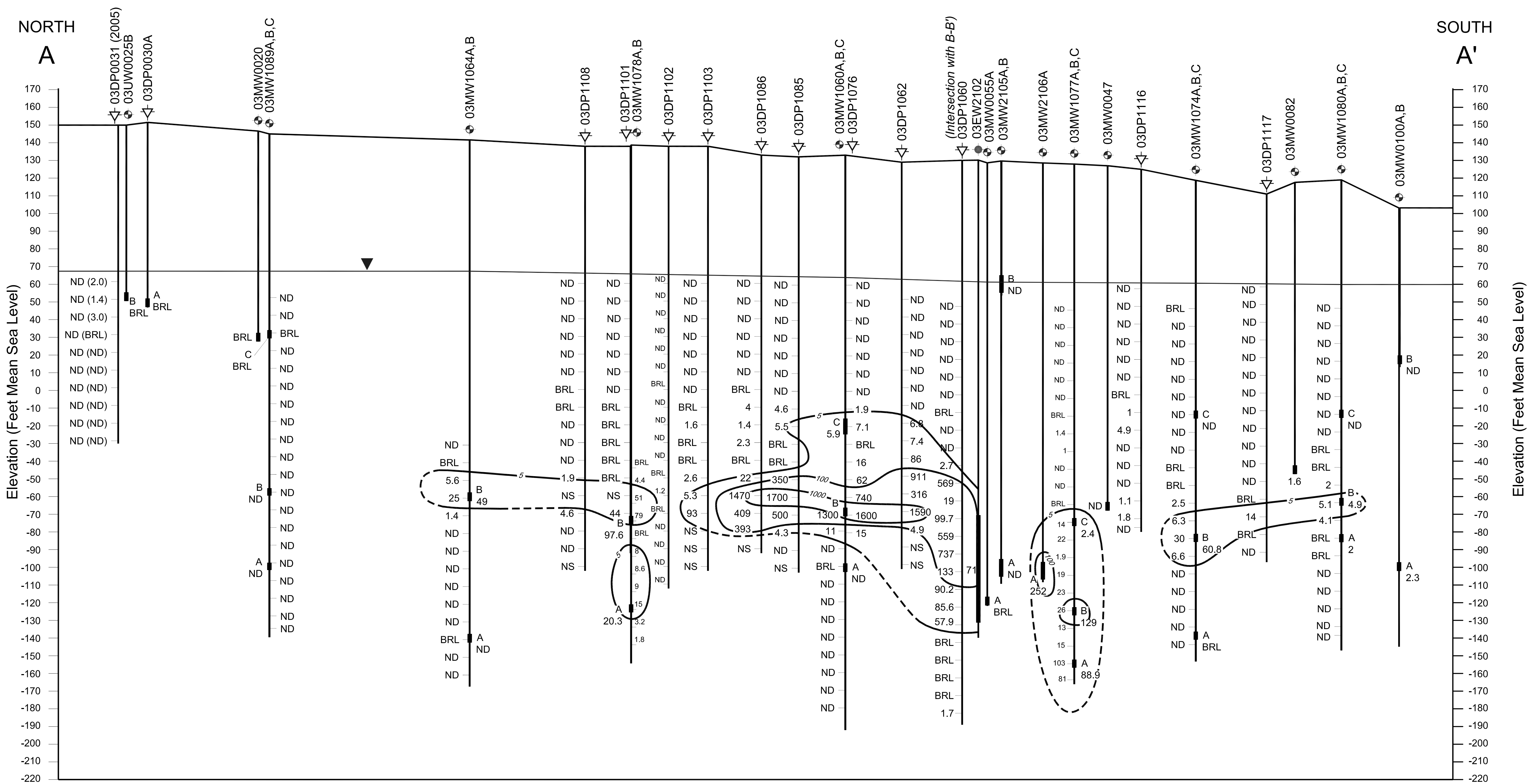
0 510 1,020
Feet

FIGURE C-2

CS-10 IN-PLUME AREA AND LOCATION OF CROSS-SECTION LINES

AFCEE - Massachusetts Military Reservation
Final CS-10 Data Gap Investigation Technical Memorandum

CH2MHILL.



Legend

Monitoring Well	BRL Below Reporting Limit	A Well Screen ID	
Extraction Well	NS Not Sampled	5 TCE Isoconcentration Contour (MCL = 5 µg/L) (Dashed Where Inferred)	
Water Table (10/2011)	BRL TCE Data (µg/L)	1.2 (2) TCE Vertical Profile Data (µg/L) (PCE Data)	
Direct Push Location			
ND Nondetect			

Data Source: AFCEE, May 2012, MMR-AFCEE Data Warehouse.

Note: Unless otherwise noted, the data shown on this cross-section were collected between 2008 and 2012 under the System Performance and Ecological Impact Monitoring Program or as part of the CS-10 Data Gap Investigation.

V: 58
H: 953
0
Feet

FIGURE C-3

CS-10 CROSS SECTION A-A' (IN-PLUME AREA)

AFCEE - Massachusetts Military Reservation

Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

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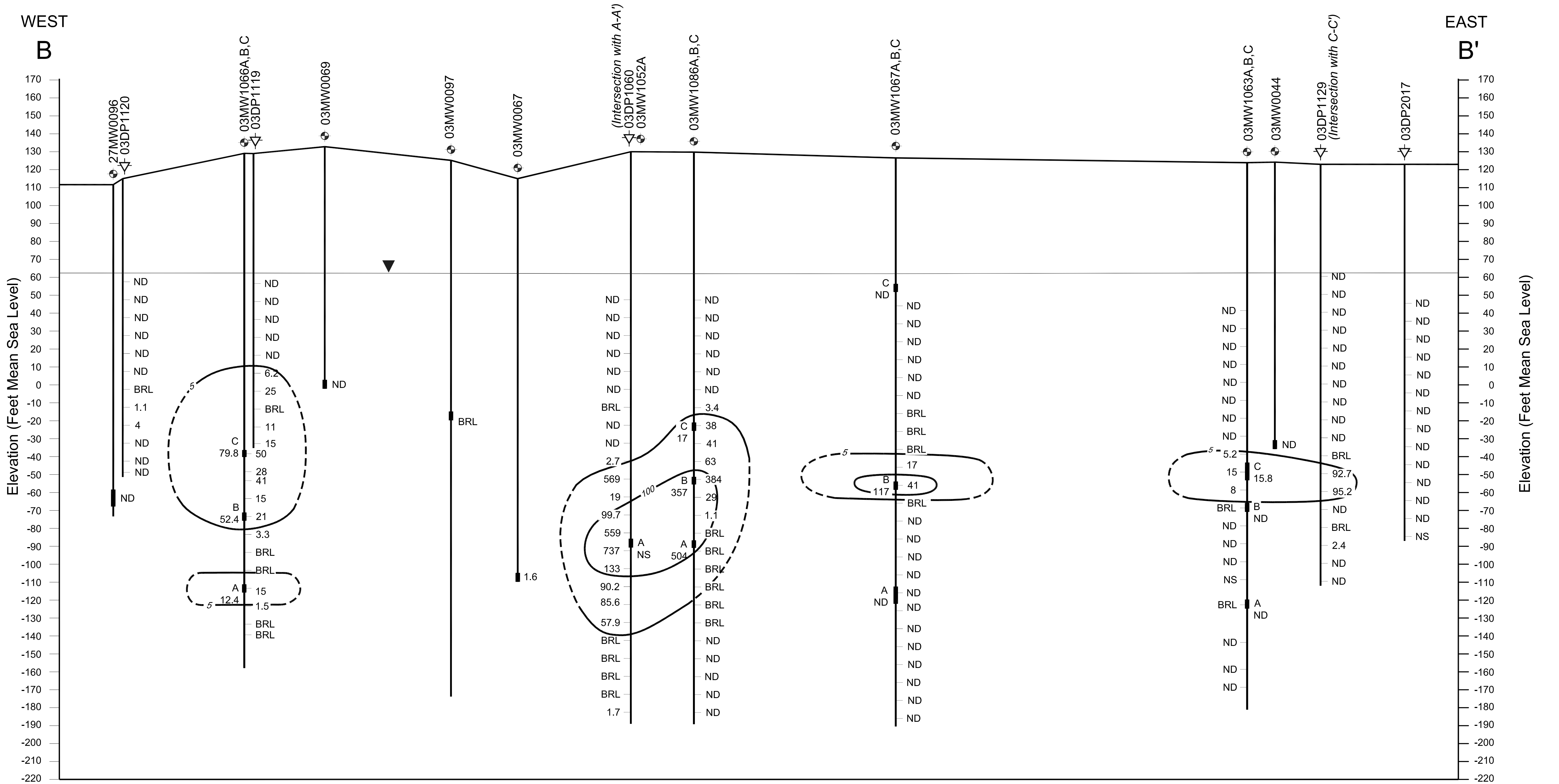

Legend

Monitoring Well	BRL	Below Reporting Limit	A	Well Screen ID
Extraction Well	NS	Not Sampled	5	TCE Isoconcentration Contour (MCL = 5 µg/L) (Dashed Where Inferred)
Water Table (10/2011)	BRL	TCE Data (µg/L)	1.2	TCE Vertical Profile Data (µg/L)
Direct Push Location				
ND	Nondetect			

Data Source: AFCEE, May 2012, MMR-AFCEE Data Warehouse.

Note: Unless otherwise noted, the data shown on this cross-section were collected between 2008 and 2012 under the System Performance and Ecological Impact Monitoring Program or as part of the CS-10 Data Gap Investigation.

V: 58
H: 532
0
Feet

FIGURE C-4

CS-10 CROSS SECTION B-B' (IN-PLUME AREA)

AFCEE - Massachusetts Military Reservation

Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

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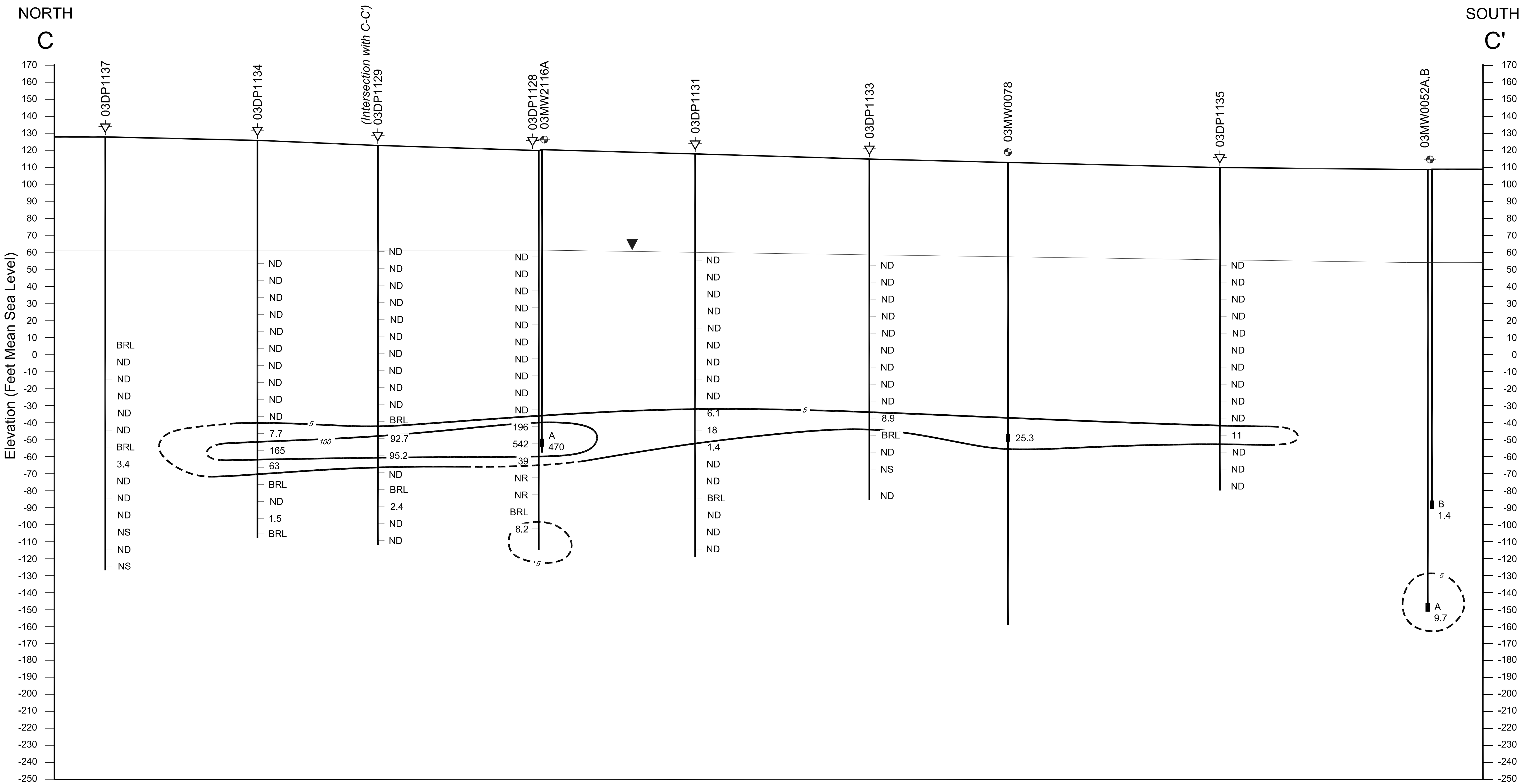

Legend

Monitoring Well	BRL	Below Reporting Limit	A	Well Screen ID
Extraction Well	NS	Not Sampled	5	TCE Isoconcentration Contour (MCL = 5 µg/L) (Dashed Where Inferred)
Water Table (12/2011 - 01/2012)	BRL	TCE Data (µg/L)	1.2	TCE Vertical Profile Data (µg/L)
Direct Push Location				
ND	Nondetect			

Note: Unless otherwise noted, the data shown on this cross-section were collected between 2008 and 2012 under the System Performance and Ecological Impact Monitoring Program or as part of the CS-10 Data Gap Investigation.

Data Source: AFCEE, May 2012, MMR-AFCEE Data Warehouse.

V: 60
H: 506
0 Feet

FIGURE C-5

CS-10 CROSS SECTION C-C' (IN-PLUME AREA)

AFCEE - Massachusetts Military Reservation

Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

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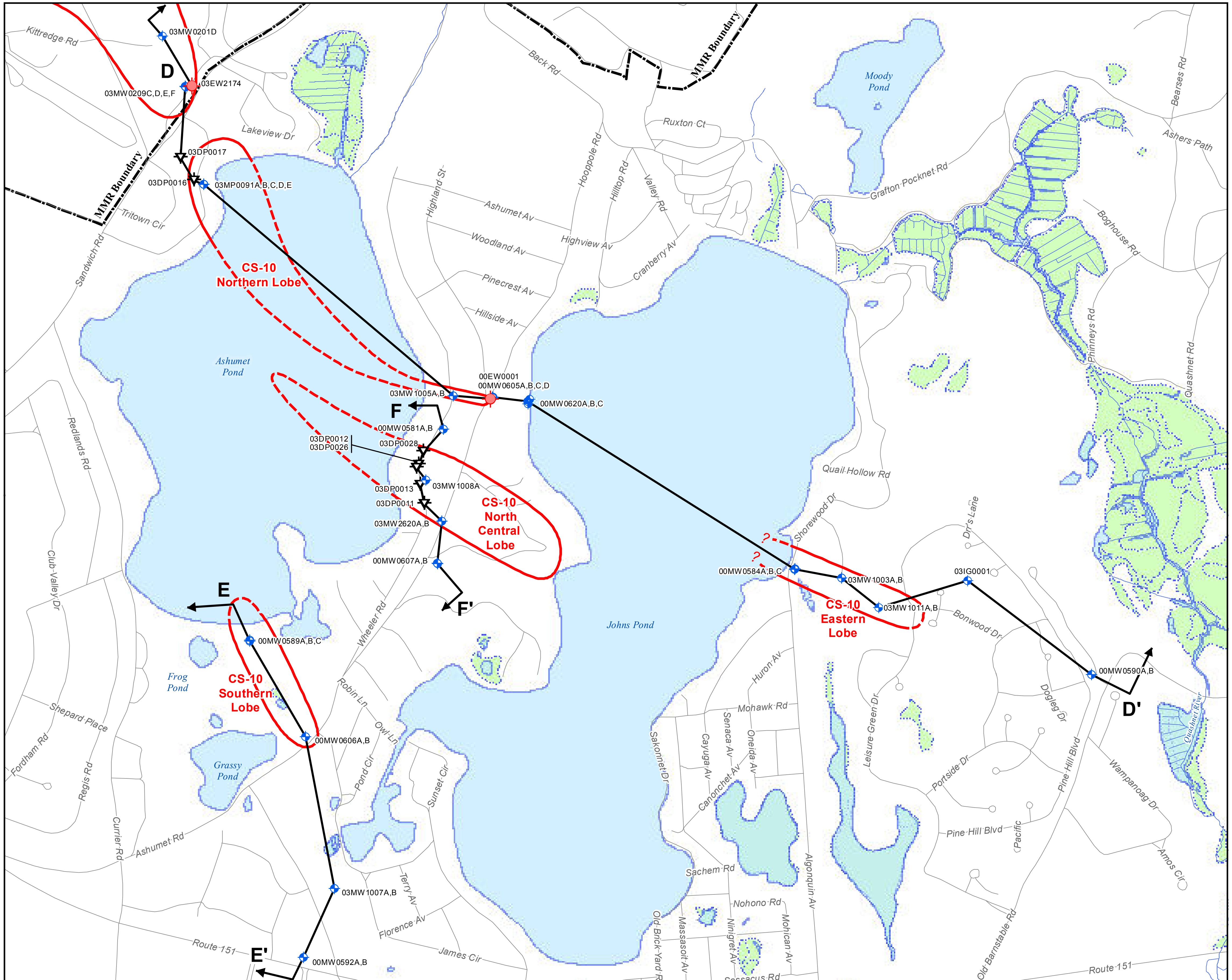

Legend

- Monitoring Well
- Direct Push Location
- Extraction Well
- CS-10 2004 Plume Boundary (Dashed Where Inferred)
- Massachusetts Military Reservation Boundary
- A A' Cross-Section Line
- Bog/Wetland

Note:
Plume depiction based on data collected through 2005 as presented in the *Final Chemical Spill-10 Leading Edge Technical Memorandum* (AFCEE 2005)

0 625 1,250 Feet

Data Source: AFCEE, May 2005, MMR-AFCEE Data Warehouse.
MMR Boundary from Massachusetts Air National Guard 2011

FIGURE C-6

CS-10 LEADING EDGE AND SANDWICH ROAD LOBES AND LOCATION OF CROSS-SECTION LINES

AFCEE - Massachusetts Military Reservation

Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

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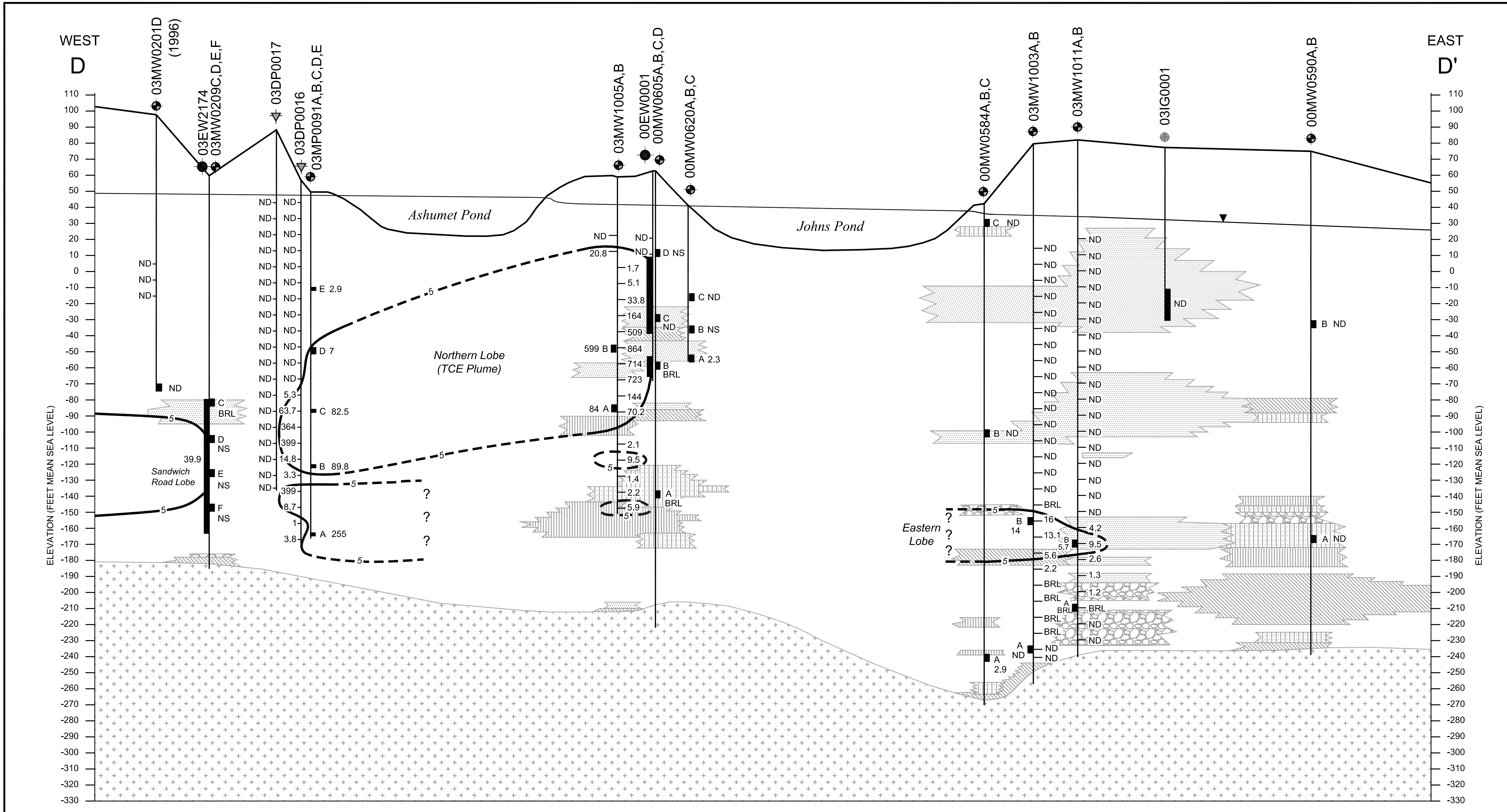

Legend

- Extraction Well
- Monitoring Well
- A Well Screen ID
- Water Table
- Direct Push Location
- Irrigation Well
- 5 Isoconcentration Contour (Based on 2003-2005 Data) (Dashed Where Inferred) (MCL = 5.0 µg/L)
- 1.7 TCE Vertical Profile Data (µg/L)
- 2.6 TCE Concentrations (µg/L)
- ND Nondetect
- BRL Below Reporting Limit
- NS Not Sampled
- Clay
- Silt
- Silty Sand
- Fine Sand
- Gravelly Sand
- Bedrock

Data Source: AFCEE, May 2005, MMR AFCEE Data Warehouse

Note: Unless otherwise noted, the data shown on this cross-section were collected between 2003 and 2005 as reported in the *Final Chemical Spill-10 Leading Edge Technical Memorandum* (AFCEE 2007).

0 V: 60 H: 1000 Feet

FIGURE C-7

CS-10 CROSS-SECTION D-D' (LEADING EDGE AND SANDWICH ROAD LOBES)

AFCEE-Massachusetts Military Reservation

Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

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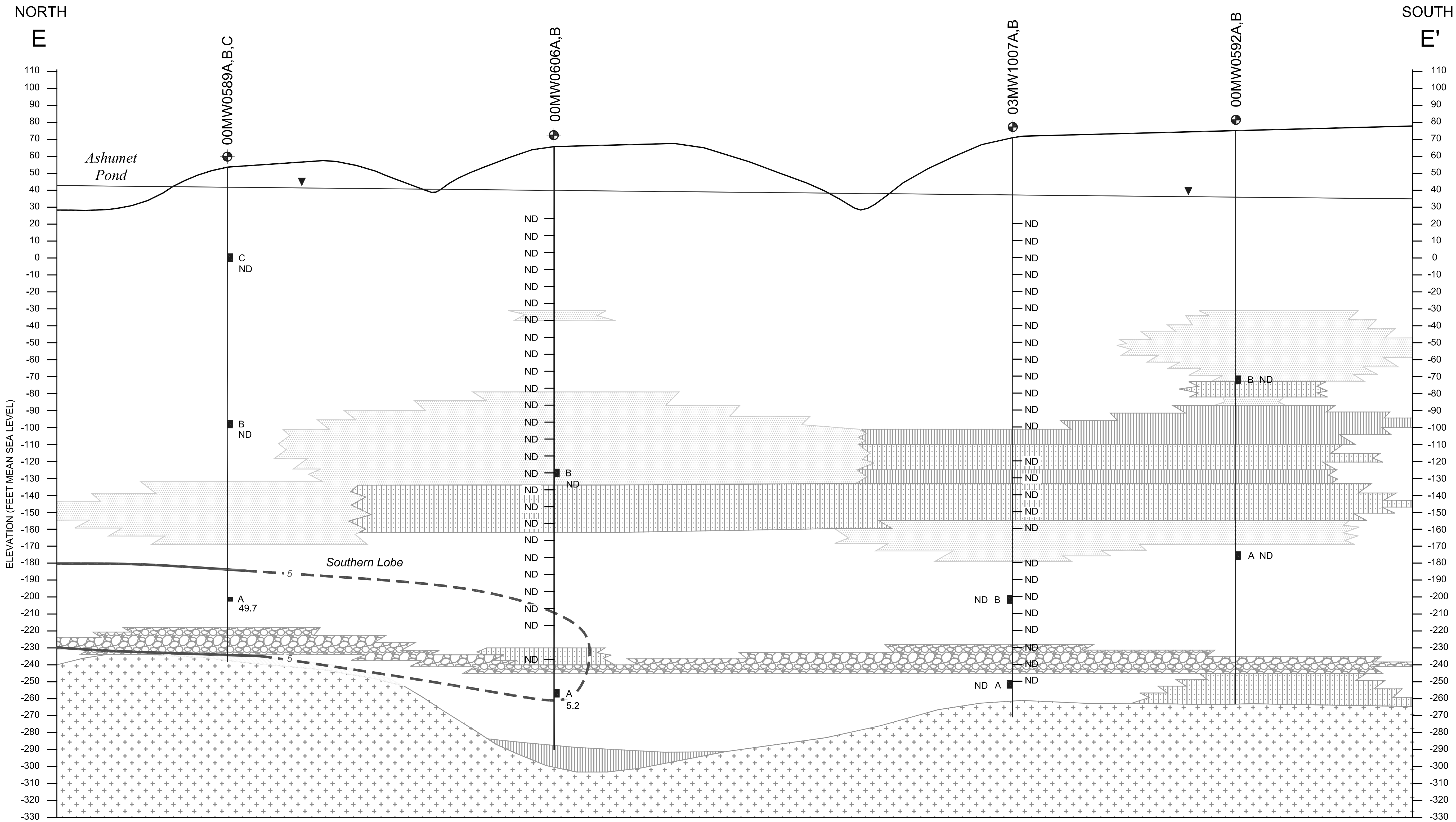

Legend

- Monitoring Well
- A Well Screen ID
- Water Table
- ND Nondetect
- 5 Isoconcentration Contour (Based on 2003 - 2005 Data) (Dashed Where Inferred) (MCL = 5.0 µg/L)
- 1.1 TCE Vertical Profile Data (µg/L)
- 2.6 TCE Concentrations (µg/L)
- Silt
- Clay
- Silty Sand
- Fine Sand
- Gravelly Sand
- Bedrock

Note: Unless otherwise noted, the data shown on this cross-section were collected between 2003 and 2005 as reported in the *Final Chemical Spill-10 Leading Edge Technical Memorandum* (AFCEE 2007).

Data Source: AFCEE, May 2005, MMR AFCEE Data Warehouse

V: 60
H: 333
0 Feet

FIGURE C-8

CS-10 CROSS-SECTION E-E' (LEADING EDGE AND SANDWICH ROAD LOBES)

AFCEE-Massachusetts Military Reservation

Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

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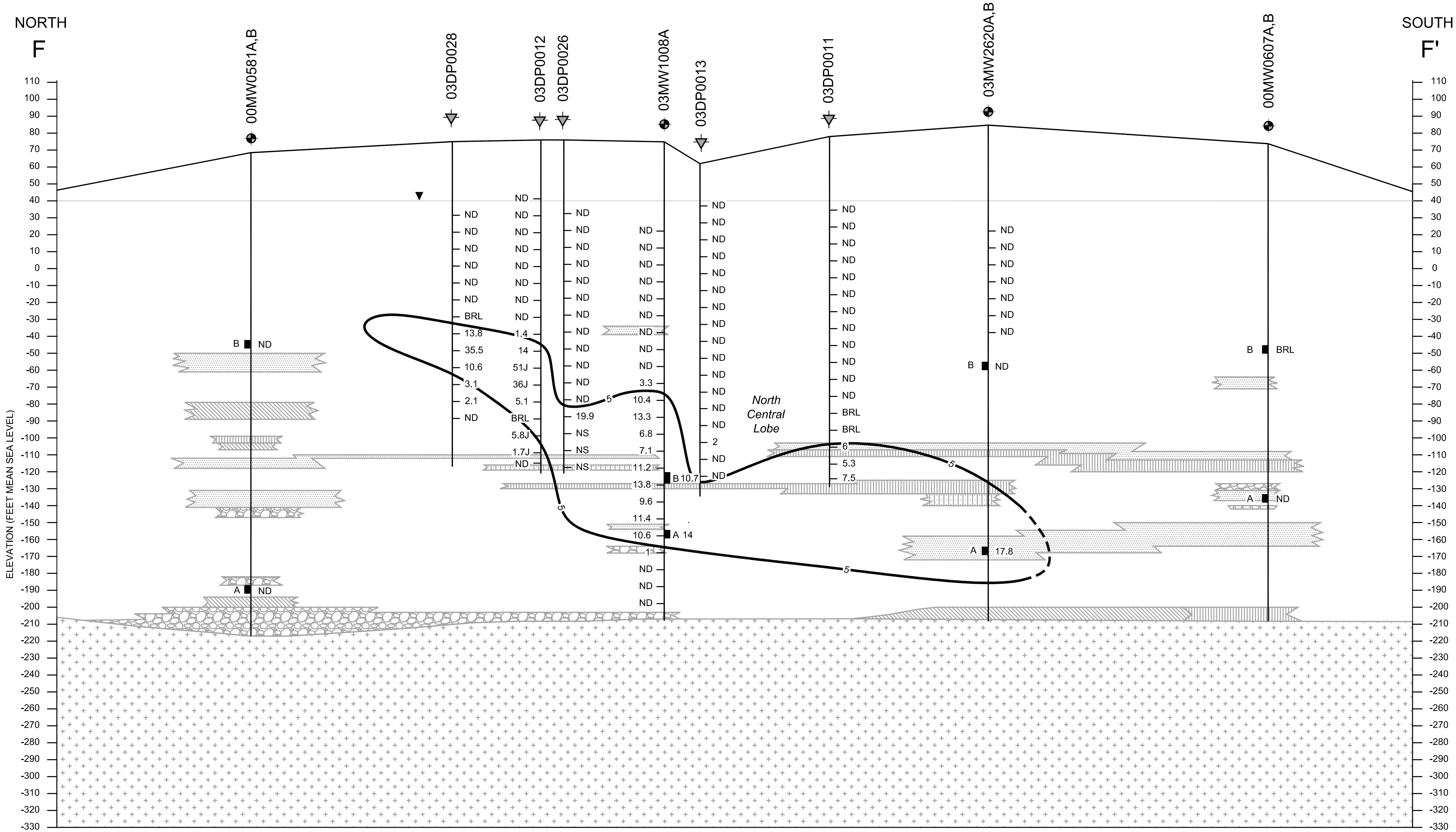

Legend

Monitoring Well	Isoconcentration Contour (Based on 2003-2005 Data) (Dashed Where Inferred) (MCL = 5.0 µg/L)	1.1 TCE Vertical Profile Data (µg/L)	Silt	Fine Sand	
A Well Screen ID	2.6 TCE Concentrations (µg/L)	ND Nondetect	Clay	Gravelly Sand	
Direct Push Location		BRL Below Reporting Limit	Silty Sand	Bedrock	
Water Table		NS Not Sampled			

Data Source: AFCEE, May 2005, MMR AFCEE Data Warehouse

Note: Unless otherwise noted, the data shown on this cross-section were collected between 2003 and 2005 as reported in the *Final Chemical Spill-10 Leading Edge Technical Memorandum* (AFCEE 2007).

V: 60
H: 150
0 Feet

FIGURE C-9

CS-10 CROSS-SECTION F-F' (LEADING EDGE AND SANDWICH ROAD LOBES)

AFCEE-Massachusetts Military Reservation
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

CH2MHILL.

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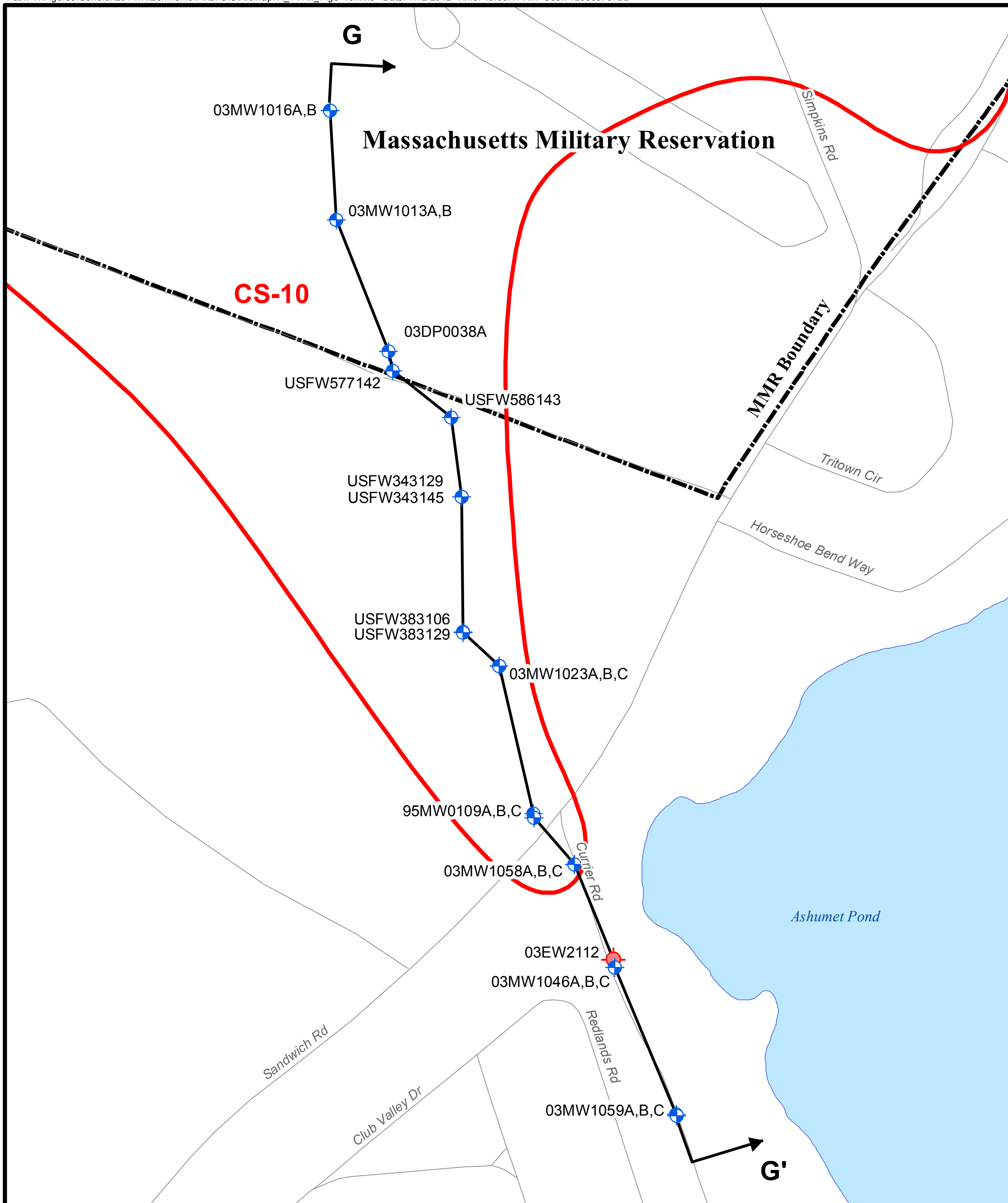


Legend

- Massachusetts Military Reservation Boundary
- Plume Boundary
- G — G' Cross-section Line
- Monitoring Well
- Extraction Well

Data Source: AFCEE, June 2012, MMR-AFCEE Data Warehouse
MMR Boundary from Massachusetts Air National Guard 2011

N

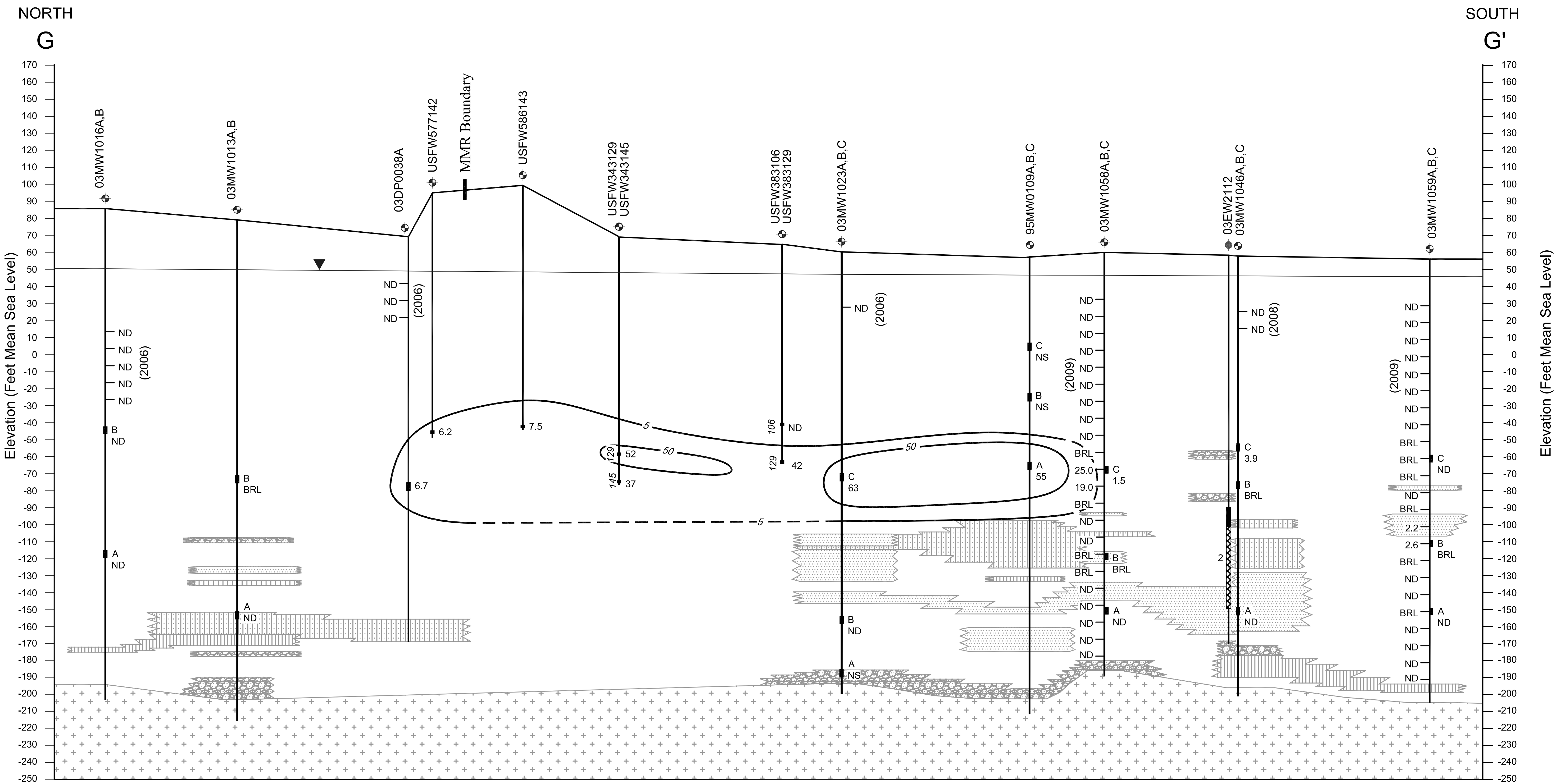
0 200 400 Feet

FIGURE C-10

CS-10 SOUTHERN TRENCH AREA AND LOCATION OF CROSS-SECTION LINE

AFCEE - Massachusetts Military Reservation
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

CH2MHILL



Legend

Monitoring Well	BRL	Below Reporting Limit	
Extraction Well	NS	Not Sampled	
Water Table (10/2011)	BRL	TCE Data (μg/L)	
ND	Nondetect		

- A — Well Screen ID
- 5 — TCE Isoconcentration Contour (MCL = 5 μg/L) (Dashed Where Inferred)
- 1.2 — TCE Vertical Profile Data (μg/L) (Date Collected)
- Extraction Well Packer
- Silt
- Silty Sand
- Fine Sand
- Gravelly Sand
- Bedrock

Data Source: AFCEE, February 2012, MMR-AFCEE Data Warehouse.

Note: Unless otherwise noted, the data shown on this cross-section were collected between 2009 and 2011 as reported in the *Chemical Spill-10 2011 Southern Trench Area Optimization Project Note* (AFCEE 2012c).

V: 60
H: 252
0 Feet

FIGURE C-11

CS-10 CROSS SECTION G-G' (SOUTHERN TRENCH AREA)

AFCEE - Massachusetts Military Reservation

Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

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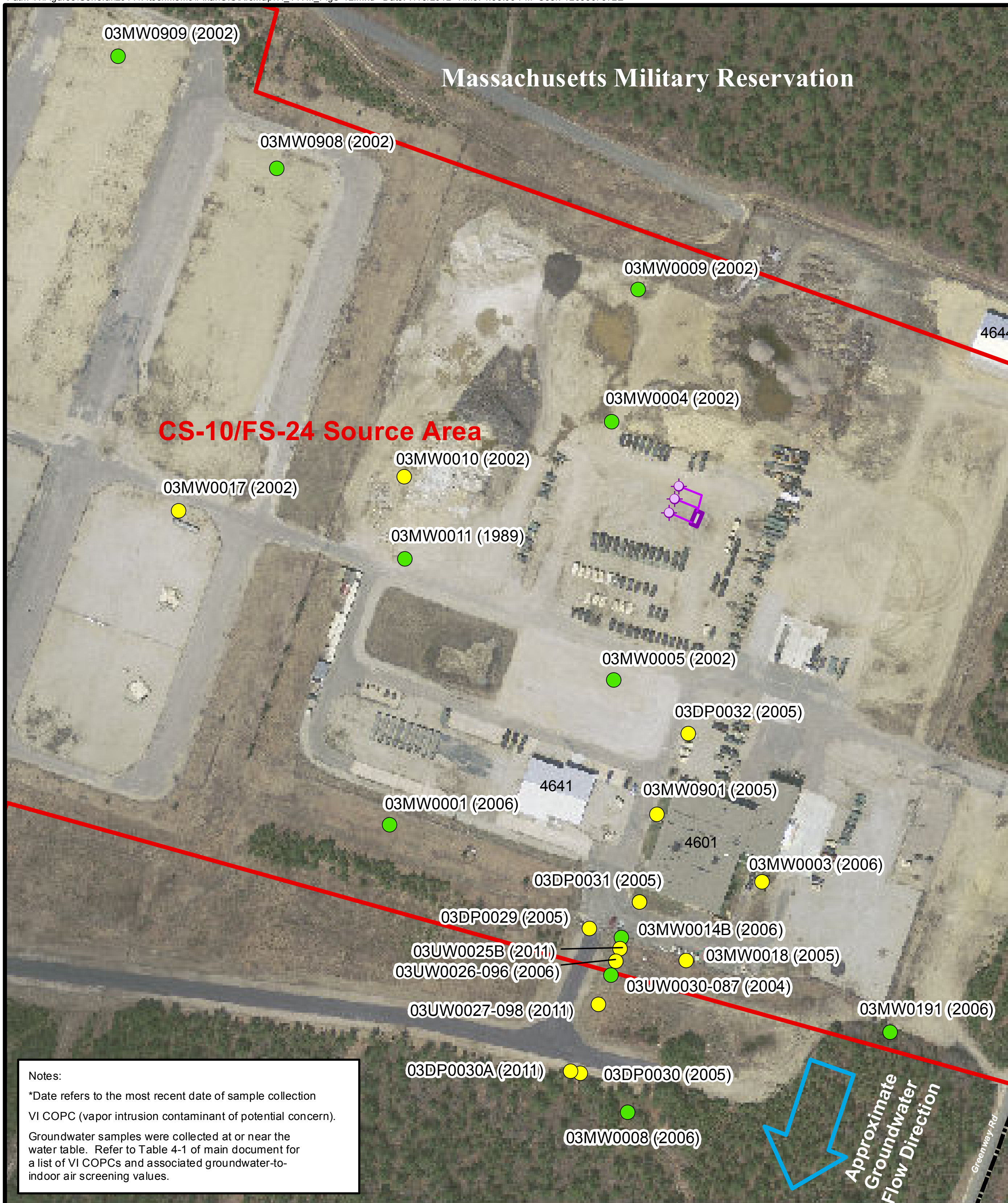
Path: Y:\Figures\General\2011\VItechmemo\Final\GIS\Arcmap\VI_11TM_FigC-12.mxd Date: 7/16/2012 Time: 1:53:03 PM User: 1268507872E



Legend

(2010) Locations with an Exceedance of a VI COPC Screening Value*

(2010) Locations With VI COPC Detection Below Its Screening Values*

(2009) Locations With No VI COPC Detections*

Massachusetts Military Reservation Boundary

Source Area

Soil Vapor Extraction Well

Soil Vapor Extraction System Pipeline

Soil Vapor Extraction System Treatment Facility

Data Source: AFCEE, June 2012, MMR-AFCEE Data Warehouse
2009 Aerial Photography from MassGIS

N

0 100 200 Feet

FIGURE C-12

CS-10/FS-24 SOURCE AREA GROUNDWATER DATA SUMMARY

AFCEE - Massachusetts Military Reservation

Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

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Table C-1
CS-10 Groundwater Data Used in Support of VI Evaluation
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Location	Date Sampled	Mid-Sample Elevation (ft msl)	Sampling Method[1]	VI COPC[2]	Result (µg/L)
In-Plume Area - CS-10/FS-24 Source Area					
03DP0029	10/31/2005	56.50	VP	TETRACHLOROETHENE (PCE)	3.1
03DP0030	11/10/2005	56.50	VP	TETRACHLOROETHENE (PCE)	BRL
03DP0030A	11/3/2011	49.55	MW	TETRACHLOROETHENE (PCE)	2.2
03DP0030A	11/3/2011	49.55	MW	TRICHLOROETHENE (TCE)	BRL
03DP0031	11/29/2005	61.50	VP	TETRACHLOROETHENE (PCE)	2.0
03DP0031	11/29/2005	51.50	VP	TETRACHLOROETHENE (PCE)	1.4
03DP0031	11/29/2005	41.50	VP	TETRACHLOROETHENE (PCE)	3.0
03DP0031	11/29/2005	31.50	VP	TETRACHLOROETHENE (PCE)	BRL
03DP0032	12/13/2005	56.50	VP	TETRACHLOROETHENE (PCE)	BRL
03MW0003	2/1/2006	67.96	MW	TETRACHLOROETHENE (PCE)	BRL
03MW0010	4/16/2002	62.80	MW	TETRACHLOROETHENE (PCE)	BRL
03MW0017	4/16/2002	62.20	MW	TETRACHLOROETHENE (PCE)	BRL
03MW0018	10/3/2005	57.90	MW	TETRACHLOROETHENE (PCE)	1.3
03MW0901	10/4/2005	62.47	MW	TETRACHLOROETHENE (PCE)	3.0
03UW0025B	11/3/2011	53.00	MW	TETRACHLOROETHENE (PCE)	1.0
03UW0025B	11/3/2011	53.00	MW	TRICHLOROETHENE (TCE)	BRL
03UW0026-096	1/31/2006	54.29	MW	TETRACHLOROETHENE (PCE)	2.6
03UW0027-098	11/3/2011	50.89	MW	TETRACHLOROETHENE (PCE)	BRL
In-Plume Area -Main Plume					
03DP1060	8/12/2008	47.50	VP	No detections of plume-related VI COPCs	
03DP1060	8/12/2008	37.50	VP	No detections of plume-related VI COPCs	
03DP1060	8/13/2008	27.50	VP	No detections of plume-related VI COPCs	
03DP1060	8/13/2008	17.50	VP	No detections of plume-related VI COPCs	
03DP1060	8/13/2008	7.50	VP	No detections of plume-related VI COPCs	
03DP1060	10/13/2008	-2.50	VP	No detections of plume-related VI COPCs	
03DP1062	11/3/2008	51.50	VP	No detections of plume-related VI COPCs	
03DP1062	11/3/2008	41.50	VP	No detections of plume-related VI COPCs	
03DP1062	11/4/2008	31.50	VP	No detections of plume-related VI COPCs	
03DP1062	11/4/2008	21.50	VP	No detections of plume-related VI COPCs	
03DP1062	11/4/2008	11.50	VP	No detections of plume-related VI COPCs	
03DP1062	11/4/2008	1.50	VP	No detections of plume-related VI COPCs	
03DP1062	11/4/2008	-8.50	VP	No detections of plume-related VI COPCs	
03DP1076	8/5/2009	59.50	VP	No detections of plume-related VI COPCs	
03DP1076	8/5/2009	49.50	VP	No detections of plume-related VI COPCs	
03DP1076	8/5/2009	39.50	VP	No detections of plume-related VI COPCs	
03DP1076	8/6/2009	29.50	VP	No detections of plume-related VI COPCs	
03DP1076	8/6/2009	19.50	VP	No detections of plume-related VI COPCs	
03DP1076	8/6/2009	9.50	VP	No detections of plume-related VI COPCs	
03DP1076	8/6/2009	-0.50	VP	No detections of plume-related VI COPCs	
03DP1085	3/22/2010	59.50	VP	No detections of plume-related VI COPCs	
03DP1085	3/22/2010	49.50	VP	No detections of plume-related VI COPCs	
03DP1085	3/22/2010	39.50	VP	No detections of plume-related VI COPCs	
03DP1085	3/22/2010	29.50	VP	No detections of plume-related VI COPCs	
03DP1085	3/22/2010	19.50	VP	No detections of plume-related VI COPCs	
03DP1085	3/23/2010	9.50	VP	No detections of plume-related VI COPCs	
03DP1085	3/23/2010	-0.50	VP	No detections of plume-related VI COPCs	
03DP1086	4/15/2010	60.50	VP	No detections of plume-related VI COPCs	
03DP1086	4/16/2010	50.50	VP	No detections of plume-related VI COPCs	
03DP1086	4/16/2010	40.50	VP	No detections of plume-related VI COPCs	
03DP1086	4/16/2010	30.50	VP	No detections of plume-related VI COPCs	
03DP1086	4/16/2010	20.50	VP	No detections of plume-related VI COPCs	
03DP1086	4/16/2010	10.50	VP	No detections of plume-related VI COPCs	
03DP1101	11/17/2010	60.50	VP	No detections of plume-related VI COPCs	
03DP1101	11/17/2010	50.50	VP	No detections of plume-related VI COPCs	
03DP1101	11/17/2010	40.50	VP	No detections of plume-related VI COPCs	
03DP1101	11/17/2010	30.50	VP	No detections of plume-related VI COPCs	
03DP1101	11/17/2010	20.50	VP	No detections of plume-related VI COPCs	
03DP1101	11/17/2010	10.50	VP	No detections of plume-related VI COPCs	

Table C-1
CS-10 Groundwater Data Used in Support of VI Evaluation
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Location	Date Sampled	Mid-Sample Elevation (ft msl)	Sampling Method[1]	VI COPC[2]	Result (µg/L)
03DP1101	11/17/2010	0.50	VP	No detections of plume-related VI COPCs	
03DP1102	12/15/2010	60.50	VP	No detections of plume-related VI COPCs	
03DP1102	12/15/2010	50.50	VP	No detections of plume-related VI COPCs	
03DP1102	12/15/2010	40.50	VP	No detections of plume-related VI COPCs	
03DP1102	12/15/2010	30.50	VP	No detections of plume-related VI COPCs	
03DP1102	12/15/2010	20.50	VP	No detections of plume-related VI COPCs	
03DP1102	12/15/2010	10.50	VP	No detections of plume-related VI COPCs	
03DP1103	12/17/2010	60.50	VP	No detections of plume-related VI COPCs	
03DP1103	12/17/2010	50.50	VP	No detections of plume-related VI COPCs	
03DP1103	12/17/2010	40.50	VP	No detections of plume-related VI COPCs	
03DP1103	12/17/2010	30.50	VP	No detections of plume-related VI COPCs	
03DP1103	12/20/2010	20.50	VP	No detections of plume-related VI COPCs	
03DP1103	12/20/2010	10.50	VP	No detections of plume-related VI COPCs	
03DP1103	12/20/2010	0.50	VP	No detections of plume-related VI COPCs	
03DP1108	3/17/2011	60.50	VP	No detections of plume-related VI COPCs	
03DP1108	3/17/2011	50.50	VP	No detections of plume-related VI COPCs	
03DP1108	3/17/2011	40.50	VP	No detections of plume-related VI COPCs	
03DP1108	3/17/2011	30.50	VP	No detections of plume-related VI COPCs	
03DP1108	3/17/2011	20.50	VP	No detections of plume-related VI COPCs	
03DP1108	3/18/2011	10.50	VP	No detections of plume-related VI COPCs	
03DP1116	5/9/2011	57.50	VP	No detections of plume-related VI COPCs	
03DP1116	5/9/2011	47.50	VP	No detections of plume-related VI COPCs	
03DP1116	5/9/2011	37.50	VP	No detections of plume-related VI COPCs	
03DP1116	5/9/2011	27.50	VP	No detections of plume-related VI COPCs	
03DP1116	5/9/2011	17.50	VP	No detections of plume-related VI COPCs	
03DP1116	5/10/2011	7.50	VP	No detections of plume-related VI COPCs	
03DP1117	5/13/2011	58.50	VP	No detections of plume-related VI COPCs	
03DP1117	5/13/2011	48.50	VP	No detections of plume-related VI COPCs	
03DP1117	5/13/2011	38.50	VP	No detections of plume-related VI COPCs	
03DP1117	5/13/2011	28.50	VP	No detections of plume-related VI COPCs	
03DP1117	5/13/2011	18.50	VP	No detections of plume-related VI COPCs	
03DP1117	5/13/2011	8.50	VP	No detections of plume-related VI COPCs	
03DP1117	5/13/2011	-1.50	VP	No detections of plume-related VI COPCs	
03DP1117	5/13/2011	-11.50	VP	No detections of plume-related VI COPCs	
03DP1117	5/16/2011	-21.50	VP	No detections of plume-related VI COPCs	
03DP1117	5/16/2011	-31.50	VP	No detections of plume-related VI COPCs	
03DP1117	5/16/2011	-41.50	VP	No detections of plume-related VI COPCs	
03DP1117	5/16/2011	-51.50	VP	No detections of plume-related VI COPCs	
03DP1119	5/23/2011	56.50	VP	No detections of plume-related VI COPCs	
03DP1119	5/23/2011	46.50	VP	No detections of plume-related VI COPCs	
03DP1119	5/23/2011	36.50	VP	No detections of plume-related VI COPCs	
03DP1119	5/24/2011	26.50	VP	No detections of plume-related VI COPCs	
03DP1119	5/24/2011	16.50	VP	No detections of plume-related VI COPCs	
03DP1120	5/26/2011	57.50	VP	No detections of plume-related VI COPCs	
03DP1120	5/26/2011	47.50	VP	No detections of plume-related VI COPCs	
03DP1120	5/26/2011	37.50	VP	No detections of plume-related VI COPCs	
03DP1120	5/26/2011	27.50	VP	No detections of plume-related VI COPCs	
03DP1120	5/26/2011	17.50	VP	No detections of plume-related VI COPCs	
03DP1120	5/26/2011	7.50	VP	No detections of plume-related VI COPCs	
03DP1128	9/19/2011	57.50	VP	No detections of plume-related VI COPCs	
03DP1128	9/20/2011	47.50	VP	No detections of plume-related VI COPCs	
03DP1128	9/20/2011	37.50	VP	No detections of plume-related VI COPCs	
03DP1128	9/20/2011	27.50	VP	No detections of plume-related VI COPCs	
03DP1128	9/20/2011	17.50	VP	No detections of plume-related VI COPCs	
03DP1128	9/20/2011	7.50	VP	No detections of plume-related VI COPCs	
03DP1128	9/20/2011	-2.50	VP	No detections of plume-related VI COPCs	
03DP1128	9/21/2011	-12.50	VP	No detections of plume-related VI COPCs	
03DP1128	9/21/2011	-22.50	VP	No detections of plume-related VI COPCs	
03DP1128	9/21/2011	-32.50	VP	No detections of plume-related VI COPCs	

Location	Date Sampled	Mid-Sample Elevation (ft msl)	Sampling Method[1]	VI COPC[2]	Result (µg/L)
03DP1129	8/17/2011	60.50	VP	No detections of plume-related VI COPCs	
03DP1129	8/17/2011	50.50	VP	No detections of plume-related VI COPCs	
03DP1129	8/17/2011	40.50	VP	No detections of plume-related VI COPCs	
03DP1129	8/17/2011	30.50	VP	No detections of plume-related VI COPCs	
03DP1129	8/18/2011	20.50	VP	No detections of plume-related VI COPCs	
03DP1129	8/18/2011	10.50	VP	No detections of plume-related VI COPCs	
03DP1129	8/18/2011	0.50	VP	No detections of plume-related VI COPCs	
03DP1129	8/18/2011	-9.50	VP	No detections of plume-related VI COPCs	
03DP1129	8/18/2011	-19.50	VP	No detections of plume-related VI COPCs	
03DP1129	8/19/2011	-29.50	VP	No detections of plume-related VI COPCs	
03DP1131	10/12/2011	55.50	VP	No detections of plume-related VI COPCs	
03DP1131	10/12/2011	45.50	VP	No detections of plume-related VI COPCs	
03DP1131	10/12/2011	35.50	VP	No detections of plume-related VI COPCs	
03DP1131	10/12/2011	25.50	VP	No detections of plume-related VI COPCs	
03DP1131	10/12/2011	15.50	VP	No detections of plume-related VI COPCs	
03DP1131	10/13/2011	5.50	VP	No detections of plume-related VI COPCs	
03DP1131	10/13/2011	-4.50	VP	No detections of plume-related VI COPCs	
03DP1131	10/13/2011	-14.50	VP	No detections of plume-related VI COPCs	
03DP1131	10/13/2011	-24.50	VP	No detections of plume-related VI COPCs	
03DP1133	11/11/2011	52.50	VP	No detections of plume-related VI COPCs	
03DP1133	11/11/2011	42.50	VP	No detections of plume-related VI COPCs	
03DP1133	11/11/2011	32.50	VP	No detections of plume-related VI COPCs	
03DP1133	11/11/2011	22.50	VP	No detections of plume-related VI COPCs	
03DP1133	11/14/2011	12.50	VP	No detections of plume-related VI COPCs	
03DP1133	11/14/2011	2.50	VP	No detections of plume-related VI COPCs	
03DP1133	11/14/2011	-7.50	VP	No detections of plume-related VI COPCs	
03DP1133	11/14/2011	-17.50	VP	No detections of plume-related VI COPCs	
03DP1133	11/14/2011	-27.50	VP	No detections of plume-related VI COPCs	
03DP1134	2/1/2012	53.50	VP	No detections of plume-related VI COPCs	
03DP1134	2/1/2012	43.50	VP	No detections of plume-related VI COPCs	
03DP1134	2/2/2012	33.50	VP	No detections of plume-related VI COPCs	
03DP1134	2/2/2012	23.50	VP	No detections of plume-related VI COPCs	
03DP1134	2/2/2012	13.50	VP	No detections of plume-related VI COPCs	
03DP1134	2/2/2012	3.50	VP	No detections of plume-related VI COPCs	
03DP1134	2/2/2012	-6.50	VP	No detections of plume-related VI COPCs	
03DP1134	2/3/2012	-16.50	VP	No detections of plume-related VI COPCs	
03DP1134	2/3/2012	-26.50	VP	No detections of plume-related VI COPCs	
03DP1134	2/3/2012	-36.50	VP	No detections of plume-related VI COPCs	
03DP1135	1/24/2012	52.50	VP	No detections of plume-related VI COPCs	
03DP1135	1/24/2012	42.50	VP	No detections of plume-related VI COPCs	
03DP1135	1/24/2012	32.50	VP	No detections of plume-related VI COPCs	
03DP1135	1/24/2012	22.50	VP	No detections of plume-related VI COPCs	
03DP1135	1/24/2012	12.50	VP	No detections of plume-related VI COPCs	
03DP1135	1/25/2012	2.50	VP	No detections of plume-related VI COPCs	
03DP1135	1/25/2012	-7.50	VP	No detections of plume-related VI COPCs	
03DP1135	1/25/2012	-17.50	VP	No detections of plume-related VI COPCs	
03DP1135	1/25/2012	-27.50	VP	No detections of plume-related VI COPCs	
03DP1135	1/26/2012	-37.50	VP	No detections of plume-related VI COPCs	
03DP2017	2/17/2011	45.50	VP	No detections of plume-related VI COPCs	
03DP2017	2/17/2011	35.50	VP	No detections of plume-related VI COPCs	
03DP2017	2/17/2011	25.50	VP	No detections of plume-related VI COPCs	
03DP2017	2/18/2011	15.50	VP	No detections of plume-related VI COPCs	
03DP2017	2/18/2011	5.50	VP	No detections of plume-related VI COPCs	
03DP2017	2/18/2011	-4.50	VP	No detections of plume-related VI COPCs	
03DP2017	2/18/2011	-14.50	VP	No detections of plume-related VI COPCs	
03DP2017	2/18/2011	-24.50	VP	No detections of plume-related VI COPCs	
03DP2017	2/22/2011	-34.50	VP	No detections of plume-related VI COPCs	
03DP2017	2/22/2011	-44.50	VP	No detections of plume-related VI COPCs	
03DP2017	2/22/2011	-54.50	VP	No detections of plume-related VI COPCs	

Table C-1
CS-10 Groundwater Data Used in Support of VI Evaluation
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Location	Date Sampled	Mid-Sample Elevation (ft msl)	Sampling Method[1]	VI COPC[2]	Result (µg/L)
03DP2017	2/23/2011	-64.50	VP	No detections of plume-related VI COPCs	
03DP2017	2/24/2011	-74.50	VP	No detections of plume-related VI COPCs	
03MW1063A	1/15/2010	41.40	VP	No detections of plume-related VI COPCs	
03MW1063A	1/15/2010	31.40	VP	No detections of plume-related VI COPCs	
03MW1063A	1/15/2010	21.40	VP	No detections of plume-related VI COPCs	
03MW1063A	1/15/2010	11.40	VP	No detections of plume-related VI COPCs	
03MW1063A	1/15/2010	1.40	VP	No detections of plume-related VI COPCs	
03MW1063A	1/15/2010	-8.60	VP	No detections of plume-related VI COPCs	
03MW1063A	1/19/2010	-18.60	VP	No detections of plume-related VI COPCs	
03MW1063A	1/19/2010	-28.60	VP	No detections of plume-related VI COPCs	
03MW1067A	4/16/2010	44.05	VP	No detections of plume-related VI COPCs	
03MW1067A	4/16/2010	34.05	VP	No detections of plume-related VI COPCs	
03MW1067A	4/16/2010	24.05	VP	No detections of plume-related VI COPCs	
03MW1067A	4/16/2010	14.05	VP	No detections of plume-related VI COPCs	
03MW1067A	4/16/2010	4.05	VP	No detections of plume-related VI COPCs	
03MW1067A	4/16/2010	-5.95	VP	No detections of plume-related VI COPCs	
03MW1067C	7/12/2011	53.85	MW	No detections of plume-related VI COPCs	
03MW1077A	8/2/2010	45.40	VP	No detections of plume-related VI COPCs	
03MW1077A	8/2/2010	35.40	VP	No detections of plume-related VI COPCs	
03MW1077A	8/3/2010	25.40	VP	No detections of plume-related VI COPCs	
03MW1077A	8/3/2010	15.40	VP	No detections of plume-related VI COPCs	
03MW1077A	8/3/2010	5.40	VP	No detections of plume-related VI COPCs	
03MW1077A	8/3/2010	-4.60	VP	No detections of plume-related VI COPCs	
03MW1080A	1/25/2011	46.50	VP	No detections of plume-related VI COPCs	
03MW1080A	1/25/2011	36.50	VP	No detections of plume-related VI COPCs	
03MW1080A	1/25/2011	26.50	VP	No detections of plume-related VI COPCs	
03MW1080A	1/26/2011	16.50	VP	No detections of plume-related VI COPCs	
03MW1080A	1/26/2011	6.50	VP	No detections of plume-related VI COPCs	
03MW1080A	1/26/2011	-3.50	VP	No detections of plume-related VI COPCs	
03MW1080A	1/26/2011	-13.50	VP	No detections of plume-related VI COPCs	
03MW1080A	1/26/2011	-23.50	VP	No detections of plume-related VI COPCs	
03MW1086A	5/23/2011	47.30	VP	No detections of plume-related VI COPCs	
03MW1086A	5/23/2011	37.30	VP	No detections of plume-related VI COPCs	
03MW1086A	5/23/2011	27.30	VP	No detections of plume-related VI COPCs	
03MW1086A	5/24/2011	17.30	VP	No detections of plume-related VI COPCs	
03MW1086A	5/24/2011	7.30	VP	No detections of plume-related VI COPCs	
03MW1086A	5/24/2011	-2.70	VP	No detections of plume-related VI COPCs	
03MW1089A	7/6/2011	52.50	VP	No detections of plume-related VI COPCs	
03MW1089A	7/6/2011	42.50	VP	No detections of plume-related VI COPCs	
Leading Edge and Sandwich Road Lobes					
00MW0584C	3/23/2006	30.32	MW	No detections of plume-related VI COPCs	
00MW0589B	5/4/2009	-97.94	MW	No detections of plume-related VI COPCs	
00MW0589C	5/4/2009	0.01	MW	No detections of plume-related VI COPCs	
00MW0605A	2/2/1999	20.80	VP	No detections of plume-related VI COPCs	
00MW0605A	2/2/1999	10.80	VP	No detections of plume-related VI COPCs	
00MW0606A	10/29/1998	23.21	VP	No detections of plume-related VI COPCs	
00MW0606A	10/29/1998	13.21	VP	No detections of plume-related VI COPCs	
00MW0606A	10/29/1998	3.21	VP	No detections of plume-related VI COPCs	
00MW0606A	10/29/1998	-6.79	VP	No detections of plume-related VI COPCs	
00MW0606A	10/29/1998	-16.79	VP	No detections of plume-related VI COPCs	
00MW0606A	10/29/1998	-26.79	VP	No detections of plume-related VI COPCs	
00MW0606A	10/29/1998	-36.79	VP	No detections of plume-related VI COPCs	
00MW0606A	10/29/1998	-46.79	VP	No detections of plume-related VI COPCs	
00MW0606A	10/29/1998	-56.79	VP	No detections of plume-related VI COPCs	
00MW0606A	10/29/1998	-66.79	VP	No detections of plume-related VI COPCs	
00MW0606A	10/30/1998	-76.79	VP	No detections of plume-related VI COPCs	
00MW0606A	10/30/1998	-86.79	VP	No detections of plume-related VI COPCs	
00MW0606A	10/30/1998	-96.79	VP	No detections of plume-related VI COPCs	
00MW0606A	10/30/1998	-106.79	VP	No detections of plume-related VI COPCs	

Table C-1
CS-10 Groundwater Data Used in Support of VI Evaluation
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Location	Date Sampled	Mid-Sample Elevation (ft msl)	Sampling Method[1]	VI COPC[2]	Result (µg/L)
00MW0606A	10/30/1998	-116.79	VP	No detections of plume-related VI COPCs	
00MW0606A	10/30/1998	-126.79	VP	No detections of plume-related VI COPCs	
00MW0606A	10/30/1998	-136.79	VP	No detections of plume-related VI COPCs	
00MW0606A	10/30/1998	-146.79	VP	No detections of plume-related VI COPCs	
00MW0606A	11/2/1998	-156.79	VP	No detections of plume-related VI COPCs	
00MW0606A	11/2/1998	-166.79	VP	No detections of plume-related VI COPCs	
00MW0606A	11/2/1998	-176.79	VP	No detections of plume-related VI COPCs	
00MW0606A	11/3/1998	-186.79	VP	No detections of plume-related VI COPCs	
00MW0606A	11/3/1998	-196.79	VP	No detections of plume-related VI COPCs	
00MW0606A	11/3/1998	-206.79	VP	No detections of plume-related VI COPCs	
00MW0606A	11/4/1998	-216.79	VP	No detections of plume-related VI COPCs	
00MW0606B	5/4/2009	-126.79	MW	No detections of plume-related VI COPCs	
03DP0011	2/2/2004	34.54	VP	No detections of plume-related VI COPCs	
03DP0011	2/2/2004	24.54	VP	No detections of plume-related VI COPCs	
03DP0011	2/2/2004	14.54	VP	No detections of plume-related VI COPCs	
03DP0011	2/2/2004	4.54	VP	No detections of plume-related VI COPCs	
03DP0011	2/2/2004	-5.46	VP	No detections of plume-related VI COPCs	
03DP0011	2/2/2004	-15.46	VP	No detections of plume-related VI COPCs	
03DP0011	2/2/2004	-25.46	VP	No detections of plume-related VI COPCs	
03DP0011	2/2/2004	-35.46	VP	No detections of plume-related VI COPCs	
03DP0011	2/3/2004	-45.46	VP	No detections of plume-related VI COPCs	
03DP0011	2/3/2004	-55.46	VP	No detections of plume-related VI COPCs	
03DP0011	2/3/2004	-65.46	VP	No detections of plume-related VI COPCs	
03DP0011	2/3/2004	-75.46	VP	No detections of plume-related VI COPCs	
03DP0012	2/13/2004	41.22	VP	No detections of plume-related VI COPCs	
03DP0012	2/13/2004	31.22	VP	No detections of plume-related VI COPCs	
03DP0012	2/13/2004	21.22	VP	No detections of plume-related VI COPCs	
03DP0012	2/13/2004	11.22	VP	No detections of plume-related VI COPCs	
03DP0012	2/13/2004	1.22	VP	No detections of plume-related VI COPCs	
03DP0012	2/13/2004	-8.78	VP	No detections of plume-related VI COPCs	
03DP0012	2/13/2004	-18.78	VP	No detections of plume-related VI COPCs	
03DP0012	2/13/2004	-28.78	VP	No detections of plume-related VI COPCs	
03DP0013	2/25/2004	37.00	VP	No detections of plume-related VI COPCs	
03DP0013	2/25/2004	27.00	VP	No detections of plume-related VI COPCs	
03DP0013	2/25/2004	17.00	VP	No detections of plume-related VI COPCs	
03DP0013	2/26/2004	7.00	VP	No detections of plume-related VI COPCs	
03DP0013	2/26/2004	-3.00	VP	No detections of plume-related VI COPCs	
03DP0013	2/26/2004	-13.00	VP	No detections of plume-related VI COPCs	
03DP0013	2/26/2004	-23.00	VP	No detections of plume-related VI COPCs	
03DP0013	2/26/2004	-33.00	VP	No detections of plume-related VI COPCs	
03DP0013	2/26/2004	-43.00	VP	No detections of plume-related VI COPCs	
03DP0013	2/26/2004	-53.00	VP	No detections of plume-related VI COPCs	
03DP0013	2/26/2004	-63.00	VP	No detections of plume-related VI COPCs	
03DP0013	2/27/2004	-73.00	VP	No detections of plume-related VI COPCs	
03DP0013	2/27/2004	-83.00	VP	No detections of plume-related VI COPCs	
03DP0013	2/27/2004	-93.00	VP	No detections of plume-related VI COPCs	
03DP0016	6/28/2004	43.00	VP	No detections of plume-related VI COPCs	
03DP0016	6/28/2004	33.00	VP	No detections of plume-related VI COPCs	
03DP0016	6/28/2004	23.00	VP	No detections of plume-related VI COPCs	
03DP0016	6/28/2004	13.00	VP	No detections of plume-related VI COPCs	
03DP0016	6/28/2004	3.00	VP	No detections of plume-related VI COPCs	
03DP0016	6/28/2004	-7.00	VP	No detections of plume-related VI COPCs	
03DP0016	6/29/2004	-17.00	VP	No detections of plume-related VI COPCs	
03DP0016	6/29/2004	-27.00	VP	No detections of plume-related VI COPCs	
03DP0016	6/29/2004	-37.00	VP	No detections of plume-related VI COPCs	
03DP0016	6/29/2004	-47.00	VP	No detections of plume-related VI COPCs	
03DP0016	6/29/2004	-57.00	VP	No detections of plume-related VI COPCs	
03DP0016	6/29/2004	-67.00	VP	No detections of plume-related VI COPCs	
03DP0017	4/19/2004	44.20	VP	No detections of plume-related VI COPCs	

Table C-1
CS-10 Groundwater Data Used in Support of VI Evaluation
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Location	Date Sampled	Mid-Sample Elevation (ft msl)	Sampling Method[1]	VI COPC[2]	Result (µg/L)
03DP0017	4/19/2004	34.20	VP	No detections of plume-related VI COPCs	
03DP0017	4/19/2004	24.20	VP	No detections of plume-related VI COPCs	
03DP0017	4/19/2004	14.20	VP	No detections of plume-related VI COPCs	
03DP0017	4/19/2004	4.20	VP	No detections of plume-related VI COPCs	
03DP0017	4/19/2004	-5.82	VP	No detections of plume-related VI COPCs	
03DP0017	4/19/2004	-15.82	VP	No detections of plume-related VI COPCs	
03DP0017	4/21/2004	-25.82	VP	No detections of plume-related VI COPCs	
03DP0017	4/21/2004	-35.82	VP	No detections of plume-related VI COPCs	
03DP0017	4/21/2004	-45.82	VP	No detections of plume-related VI COPCs	
03DP0017	4/21/2004	-55.82	VP	No detections of plume-related VI COPCs	
03DP0017	4/21/2004	-65.82	VP	No detections of plume-related VI COPCs	
03DP0017	4/22/2004	-75.82	VP	No detections of plume-related VI COPCs	
03DP0017	4/22/2004	-85.82	VP	No detections of plume-related VI COPCs	
03DP0017	4/22/2004	-95.82	VP	No detections of plume-related VI COPCs	
03DP0017	4/22/2004	-105.82	VP	No detections of plume-related VI COPCs	
03DP0017	4/22/2004	-115.82	VP	No detections of plume-related VI COPCs	
03DP0017	4/22/2004	-125.82	VP	No detections of plume-related VI COPCs	
03DP0017	4/22/2004	-135.82	VP	No detections of plume-related VI COPCs	
03DP0026	3/16/2005	35.00	VP	No detections of plume-related VI COPCs	
03DP0026	3/16/2005	25.00	VP	No detections of plume-related VI COPCs	
03DP0026	3/16/2005	15.00	VP	No detections of plume-related VI COPCs	
03DP0026	3/16/2005	5.00	VP	No detections of plume-related VI COPCs	
03DP0026	3/18/2005	-5.00	VP	No detections of plume-related VI COPCs	
03DP0026	3/18/2005	-15.00	VP	No detections of plume-related VI COPCs	
03DP0026	3/18/2005	-25.00	VP	No detections of plume-related VI COPCs	
03DP0026	3/18/2005	-35.00	VP	No detections of plume-related VI COPCs	
03DP0026	3/18/2005	-45.00	VP	No detections of plume-related VI COPCs	
03DP0026	3/18/2005	-55.00	VP	No detections of plume-related VI COPCs	
03DP0026	3/18/2005	-65.00	VP	No detections of plume-related VI COPCs	
03DP0026	3/21/2005	-75.00	VP	No detections of plume-related VI COPCs	
03DP0028	3/31/2005	32.02	VP	No detections of plume-related VI COPCs	
03DP0028	3/31/2005	22.02	VP	No detections of plume-related VI COPCs	
03DP0028	3/31/2005	12.02	VP	No detections of plume-related VI COPCs	
03DP0028	3/31/2005	2.02	VP	No detections of plume-related VI COPCs	
03DP0028	3/31/2005	-7.98	VP	No detections of plume-related VI COPCs	
03DP0028	3/31/2005	-17.98	VP	No detections of plume-related VI COPCs	
03MW0201D	10/23/1996	4.72	VP	No detections of plume-related VI COPCs	
03MW0201D	10/23/1996	-5.28	VP	No detections of plume-related VI COPCs	
03MW0201D	10/23/1996	-15.28	VP	No detections of plume-related VI COPCs	
03MW1003A	7/13/2004	11.20	VP	No detections of plume-related VI COPCs	
03MW1003A	7/13/2004	1.20	VP	No detections of plume-related VI COPCs	
03MW1003A	7/13/2004	-8.80	VP	No detections of plume-related VI COPCs	
03MW1003A	7/13/2004	-18.80	VP	No detections of plume-related VI COPCs	
03MW1003A	7/13/2004	-28.80	VP	No detections of plume-related VI COPCs	
03MW1003A	7/13/2004	-38.80	VP	No detections of plume-related VI COPCs	
03MW1003A	7/13/2004	-48.80	VP	No detections of plume-related VI COPCs	
03MW1003A	7/14/2004	-58.80	VP	No detections of plume-related VI COPCs	
03MW1003A	7/15/2004	-68.80	VP	No detections of plume-related VI COPCs	
03MW1003A	7/15/2004	-78.80	VP	No detections of plume-related VI COPCs	
03MW1003A	7/16/2004	-88.80	VP	No detections of plume-related VI COPCs	
03MW1003A	7/16/2004	-98.80	VP	No detections of plume-related VI COPCs	
03MW1003A	7/16/2004	-108.80	VP	No detections of plume-related VI COPCs	
03MW1003A	7/16/2004	-118.80	VP	No detections of plume-related VI COPCs	
03MW1003A	7/19/2004	-128.80	VP	No detections of plume-related VI COPCs	
03MW1003A	7/21/2004	-138.80	VP	No detections of plume-related VI COPCs	
03MW1005A	6/1/2004	22.95	VP	No detections of plume-related VI COPCs	
03MW1008A	8/30/2004	22.16	VP	No detections of plume-related VI COPCs	
03MW1008A	8/30/2004	12.16	VP	No detections of plume-related VI COPCs	
03MW1008A	8/30/2004	2.16	VP	No detections of plume-related VI COPCs	

Location	Date Sampled	Mid-Sample Elevation (ft msl)	Sampling Method[1]	VI COPC[2]	Result (µg/L)
03MW1008A	8/30/2004	-7.84	VP	No detections of plume-related VI COPCs	
03MW1008A	8/30/2004	-17.84	VP	No detections of plume-related VI COPCs	
03MW1008A	8/31/2004	-27.84	VP	No detections of plume-related VI COPCs	
03MW1008A	8/31/2004	-37.84	VP	No detections of plume-related VI COPCs	
03MW1008A	8/31/2004	-47.84	VP	No detections of plume-related VI COPCs	
03MW1008A	8/31/2004	-57.84	VP	No detections of plume-related VI COPCs	
03MW1011A	2/14/2005	20.46	VP	No detections of plume-related VI COPCs	
03MW1011A	2/14/2005	10.46	VP	No detections of plume-related VI COPCs	
03MW1011A	2/14/2005	0.46	VP	No detections of plume-related VI COPCs	
03MW1011A	2/15/2005	-9.54	VP	No detections of plume-related VI COPCs	
03MW1011A	2/15/2005	-19.54	VP	No detections of plume-related VI COPCs	
03MW1011A	2/15/2005	-29.54	VP	No detections of plume-related VI COPCs	
03MW1011A	2/15/2005	-39.54	VP	No detections of plume-related VI COPCs	
03MW1011A	2/15/2005	-49.54	VP	No detections of plume-related VI COPCs	
03MW1011A	2/15/2005	-59.54	VP	No detections of plume-related VI COPCs	
03MW1011A	2/16/2005	-69.54	VP	No detections of plume-related VI COPCs	
03MW1011A	2/17/2005	-79.54	VP	No detections of plume-related VI COPCs	
03MW1011A	2/18/2005	-89.54	VP	No detections of plume-related VI COPCs	
03MW1011A	2/18/2005	-99.54	VP	No detections of plume-related VI COPCs	
03MW1011A	2/18/2005	-109.54	VP	No detections of plume-related VI COPCs	
03MW1011A	2/18/2005	-119.54	VP	No detections of plume-related VI COPCs	
03MW1011A	2/21/2005	-129.54	VP	No detections of plume-related VI COPCs	
03MW1011A	2/21/2005	-139.54	VP	No detections of plume-related VI COPCs	
03MW1011A	2/21/2005	-149.54	VP	No detections of plume-related VI COPCs	
03MW2620A	7/22/2000	22.23	VP	No detections of plume-related VI COPCs	
03MW2620A	7/22/2000	12.23	VP	No detections of plume-related VI COPCs	
03MW2620A	7/22/2000	2.23	VP	No detections of plume-related VI COPCs	
03MW2620A	7/24/2000	-7.77	VP	No detections of plume-related VI COPCs	
03MW2620A	7/24/2000	-17.77	VP	No detections of plume-related VI COPCs	
03MW2620A	7/24/2000	-27.77	VP	No detections of plume-related VI COPCs	
03MW2620B	12/16/2010	-57.47	MW	No detections of plume-related VI COPCs	
Southern Trench Area					
03DP0038A	1/27/2006	41.79	VP	No detections of plume-related VI COPCs	
03DP0038A	1/27/2006	31.79	VP	No detections of plume-related VI COPCs	
03DP0038A	1/27/2006	21.79	VP	No detections of plume-related VI COPCs	
03MW1016A	1/19/2006	13.35	VP	No detections of plume-related VI COPCs	
03MW1016A	1/19/2006	3.35	VP	No detections of plume-related VI COPCs	
03MW1016A	1/19/2006	-6.65	VP	No detections of plume-related VI COPCs	
03MW1016A	1/19/2006	-16.65	VP	No detections of plume-related VI COPCs	
03MW1016A	1/19/2006	-26.65	VP	No detections of plume-related VI COPCs	
03MW1023A	12/5/2006	27.88	VP	No detections of plume-related VI COPCs	
03MW1046A	3/17/2008	25.42	VP	No detections of plume-related VI COPCs	
03MW1046A	3/17/2008	15.42	VP	No detections of plume-related VI COPCs	
03MW1058A	10/28/2009	32.55	VP	No detections of plume-related VI COPCs	
03MW1058A	10/29/2009	22.55	VP	No detections of plume-related VI COPCs	
03MW1058A	10/29/2009	12.55	VP	No detections of plume-related VI COPCs	
03MW1058A	10/29/2009	-7.45	VP	No detections of plume-related VI COPCs	
03MW1058A	10/29/2009	-17.45	VP	No detections of plume-related VI COPCs	
03MW1058A	10/29/2009	-27.45	VP	No detections of plume-related VI COPCs	
03MW1058A	10/29/2009	-37.45	VP	No detections of plume-related VI COPCs	
03MW1058A	10/29/2009	-47.45	VP	No detections of plume-related VI COPCs	
03MW1058A	10/30/2009	-57.45	VP	No detections of plume-related VI COPCs	
03MW1059A	10/12/2009	28.63	VP	No detections of plume-related VI COPCs	
03MW1059A	10/13/2009	18.63	VP	No detections of plume-related VI COPCs	
03MW1059A	10/13/2009	8.63	VP	No detections of plume-related VI COPCs	
03MW1059A	10/13/2009	-1.37	VP	No detections of plume-related VI COPCs	

Table C-1
CS-10 Groundwater Data Used in Support of VI Evaluation
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Location	Date Sampled	Mid-Sample Elevation (ft msl)	Sampling Method[1]	VI COPC[2]	Result (µg/L)
03MW1059A	10/14/2009	-11.37	VP	No detections of plume-related VI COPCs	
03MW1059A	10/14/2009	-21.37	VP	No detections of plume-related VI COPCs	
03MW1059A	10/14/2009	-31.37	VP	No detections of plume-related VI COPCs	
03MW1059A	10/14/2009	-41.37	VP	No detections of plume-related VI COPCs	

Data Source: AFCEE, June 2012, MMR-AFCEE Data Warehouse

Notes:

1. Sample collection method:
   VP = vertical profile groundwater sampling (direct push, rotosonic, or screened hollow-stem auger drilling methods)
   MW = fixed monitoring well
2. See Table 4-1 of the main document for a complete list of VI COPCs.

The data summarized in this table specifically support the CS-10 clean water lens VI evaluation and typically include the most recent sampling results for each location for the plume-related VI COPCs only. If additional historic sampling data exist, they are available for review in the AFCEE-MMR Data Warehouse.

Vertical profile data presented only include the relevant sample intervals used to support this CS-10 VI evaluation; analytical data from deeper sample intervals are available in the AFCEE MMR Data Warehouse.

Key:
BRL = below the reporting limit
COPC = contaminant of potential concern
CS-10 = Chemical Spill-10
FS-24 = Fuel Spill-24
ft msl = feet mean sea level
VI = vapor intrusion
µg/L = micrograms per liter

Table C-2
CS-10 Well Construction and Sample Location Information
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Location	Northing (ft)	Easting (ft)	Surface Elevation (ft msl)	Measuring Point Elevation (ft msl)	Total Well Depth (ft bgs)	Top Screen Depth (ft bgs)	Bottom Screen Depth (ft bgs)	Top Screen Elevation (ft msl)	Bottom Screen Elevation (ft msl)	Screen Length (ft)
In-Plume Area										
03DP1060	242959	859015	130	NA	NA	NA	NA	NA	NA	NA
03DP1062	243336	859432	129	NA	NA	NA	NA	NA	NA	NA
03DP1076	243878	859503	132	NA	NA	NA	NA	NA	NA	NA
03DP1085	244270	859635	132	NA	NA	NA	NA	NA	NA	NA
03DP1086	244583	859785	133	NA	NA	NA	NA	NA	NA	NA
03DP1101	245635	860340	138	NA	NA	NA	NA	NA	NA	NA
03DP1102	245281	860292	138	NA	NA	NA	NA	NA	NA	NA
03DP1103	244978	860086	138	NA	NA	NA	NA	NA	NA	NA
03DP1108	245815	860721	138	NA	NA	NA	NA	NA	NA	NA
03DP1116	241534	858442	125	NA	NA	NA	NA	NA	NA	NA
03DP1117	240852	857499	111	NA	NA	NA	NA	NA	NA	NA
03DP1119	243523	857279	129	NA	NA	NA	NA	NA	NA	NA
03DP1120	243825	856759	115	NA	NA	NA	NA	NA	NA	NA
03DP1128	241209	862171	120	NA	NA	NA	NA	NA	NA	NA
03DP1129	242003	862282	123	NA	NA	NA	NA	NA	NA	NA
03DP1131	240455	861983	118	NA	NA	NA	NA	NA	NA	NA
03DP1133	239630	861714	115	NA	NA	NA	NA	NA	NA	NA
03DP1134	242601	862246	126	NA	NA	NA	NA	NA	NA	NA
03DP1135	238294	862019	110	NA	NA	NA	NA	NA	NA	NA
03DP2017	241661	862543	123	NA	NA	NA	NA	NA	NA	NA
03MW1063A	242068	861914	124	123.32	249	243.57	248.68	-119.67	-124.78	5.11
03MW1067A	242461	860160	127	126.47	250	240.44	250.09	-113.89	-123.54	9.65
03MW1067C	242461	860159	127	126.46	75	70.19	74.77	56.36	51.78	4.58
03MW1077A	242137	858590	128	127.35	285	280.06	284.69	-152.13	-156.76	4.63
03MW1080A	240189	857699	119	118.68	205	200.22	204.84	-81.22	-85.84	4.62
03MW1086A	243002	859335	130	129.58	221	216.44	220.70	-86.64	-90.90	4.26
03MW1089A	248305	862276	145	144.68	247	242.36	246.59	-97.36	-101.59	4.23
Leading Edge and Sandwich Road Lobes										
00MW0584A	230336	869057	43	42.36	286	281.00	286.00	-238.28	-243.28	5
00MW0589A	229648	863783	54	53.25	256	251.30	256.30	-197.69	-202.69	5
00MW0589B	229648	863783	54	53.23	154	149.05	154.05	-95.44	-100.44	5
00MW0589C	229637	863783	54	53.48	57	51.10	56.10	2.70	-2.30	5
00MW0605A	231992	866133	63	62.74	205	199.50	204.50	-136.20	-141.20	5
00MW0606A	228714	864322	66	65.34	325	320.00	325.00	-254.29	-259.29	5
00MW0606B	228715	864321	66	65.25	195	190.00	195.00	-124.29	-129.29	5
03DP0011	230961	865473	78	NA	NA	NA	NA	NA	NA	NA
03DP0012	231344	865416	76	NA	NA	NA	NA	NA	NA	NA
03DP0013	231148	865433	62	NA	NA	NA	NA	NA	NA	NA
03DP0016	234094	863243	57	NA	NA	NA	NA	NA	NA	NA
03DP0017	234313	863114	88	88.04	224	214.00	224.00	-125.72	-135.72	10
03DP0026	231315	865400	79	NA	NA	NA	NA	NA	NA	NA
03DP0028	231467	865461	76	NA	NA	NA	NA	NA	NA	NA
03MW0201D	235496	862936	98	99.83	173	167.50	172.50	-69.78	-74.78	5
03MW1003A	230246	869512	84	83.22	325	319.55	324.55	-235.85	-240.85	5
03MW1005A	232011	865751	60	60.00	149	143.21	148.21	-82.76	-87.76	5

Table C-2
CS-10 Well Construction and Sample Location Information
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Location	Northing (ft)	Easting (ft)	Surface Elevation (ft msl)	Measuring Point Elevation (ft msl)	Total Well Depth (ft bgs)	Top Screen Depth (ft bgs)	Bottom Screen Depth (ft bgs)	Top Screen Elevation (ft msl)	Bottom Screen Elevation (ft msl)	Screen Length (ft)
03MW1008A	231198	865490	85	84.24	244	239.00	244.00	-154.34	-159.34	5
03MW1011A	229964	869872	83	85.18	295	290.00	295.00	-207.04	-212.04	5
03MW2620A	230801	865643	85	84.07	254	248.90	253.90	-164.17	-169.17	5
03MW2620B	230801	865642	85	84.1	145	139.70	144.70	-54.97	-59.97	5
Southern Trench Area										
03DP0038A	234103	861375	69	68.99	149	144.46	149.46	-75.17	-80.17	5
03MW1016A	234825	861198	86	85.47	206	201.03	205.60	-115.18	-119.75	5
03MW1023A	233162	861704	60	59.73	251	245.29	250.00	-184.91	-189.62	5
03MW1046A	232259	862052	58	57.67	212	206.60	211.41	-148.68	-153.49	5
03MW1058A	232568	861931	60	59.5	213	208.76	213.06	-148.71	-153.01	5
03MW1059A	231820	862235	56	55.5	210	205.10	209.50	-148.97	-153.37	5

Data Source: AFCEE, June 2012, MMR-AFCEE Data Warehouse

Key:
bgs = below ground surface
CS-10 = Chemical Spill-10
ft = feet
msl = mean sea level
NA = data not available; locations are direct push borehole vertical profile locations and have no permanent screens installed.

Table C-3
Comparison of VI COPC Concentrations in CS-10 Source Area Groundwater to Applicable Groundwater-to-Indoor Air Screening Values
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Location	Date	Mid-screen elevation (ft msl)	Sampling Method[1]	VI COPC[2]	Result	DL	RL	MCP Method 1 GW-2 Standard[3] (µg/L)	VI Screening Value Exceeded?	Generic Unrestricted Groundwater Screening Value[4] (µg/L)	VI Screening Value Exceeded?
					All units = µg/L						
03DP0029	10/31/2005	56.50	VP	TETRACHLOROETHENE (PCE)	3.1	0.27	1	50	No	13	No
03DP0030	11/10/2005	56.50	VP	TETRACHLOROETHENE (PCE)	BRL	0.27	1	50	No	13	No
03DP0030A	11/3/2011	49.55	MW	TETRACHLOROETHENE (PCE)	2.2	0.19	1	50	No	13	No
03DP0030A	11/3/2011	49.55	MW	TRICHLOROETHENE (TCE)	BRL	0.2	1	30	No	5	No
03DP0031	11/29/2005	61.50	VP	TETRACHLOROETHENE (PCE)	2.0	0.27	1	50	No	13	No
03DP0032	12/13/2005	56.50	VP	TETRACHLOROETHENE (PCE)	BRL	0.27	1	50	No	13	No
03MW0001	2/23/2006	67.84	MW	No VI COPCs detected	ND	--	--	--	--	--	--
03MW0003	2/1/2006	67.96	MW	TETRACHLOROETHENE (PCE)	BRL	0.27	1	50	No	13	No
03MW0004	4/16/2002	65.45	MW	No VI COPCs detected	ND	--	--	--	--	--	--
03MW0005	4/16/2002	68.37	MW	No VI COPCs detected	ND	--	--	--	--	--	--
03MW0008	2/1/2006	67.98	MW	No VI COPCs detected	ND	--	--	--	--	--	--
03MW0009	4/16/2002	64.21	MW	No VI COPCs detected	ND	--	--	--	--	--	--
03MW0010	4/16/2002	62.80	MW	TETRACHLOROETHENE (PCE)	BRL	0.146	1	50	No	13	No
03MW0011	10/12/1989	64.10	MW	No VI COPCs detected	ND	--	--	--	--	--	--
03MW0014B	2/23/2006	57.91	MW	No VI COPCs detected	ND	--	--	--	--	--	--
03MW0017	4/16/2002	62.20	MW	TETRACHLOROETHENE (PCE)	BRL	0.146	1	50	No	13	No
03MW0018	10/3/2005	57.90	MW	TETRACHLOROETHENE (PCE)	1.3	0.27	1	50	No	13	No
03MW0191	2/27/2006	49.80	MW	No VI COPCs detected	ND	--	--	--	--	--	--
03MW0901	10/4/2005	62.47	MW	TETRACHLOROETHENE (PCE)	3.0	0.27	1	50	No	13	No
03MW0908	4/16/2002	65.17	MW	No VI COPCs detected	ND	--	--	--	--	--	--
03MW0909	4/16/2002	64.94	MW	No VI COPCs detected	ND	--	--	--	--	--	--
03UW0025B	11/3/2011	53.00	MW	TETRACHLOROETHENE (PCE)	1.0	0.19	1	50	No	13	No
03UW0025B	11/3/2011	53.00	MW	TRICHLOROETHENE (TCE)	BRL	0.2	1	30	No	5	No
03UW0026-096	1/31/2006	54.29	MW	TETRACHLOROETHENE (PCE)	2.6	0.27	1	50	No	13	No
03UW0027-098	11/3/2011	50.89	MW	TETRACHLOROETHENE (PCE)	BRL	0.19	1	50	No	13	No
03UW0030-087	1/13/2004	62.39	MW	No VI COPCs detected	ND	--	--	--	--	--	--

Data Source: AFCEE, June 2012, MMR-AFCEE Data Warehouse

Notes:

1. Sample collection method:
   VP = vertical profile groundwater sampling (direct push, rotosonic, or screened hollow-stem auger drilling methods)
   MW = fixed monitoring well
2. See Table 4-1 of the main document for a complete list of VI COPCs and associated MassDEP MCP Method 1 Groundwater-2 screening values and generic unrestricted groundwater screening values
3. 310 CMR 40.0974(2) http://www.mass.gov/dep/cleanup/laws/0974_2.htm.
4. EPA, 2002, Draft Guidance for Evaluating the VI to Indoor Air Pathway from Groundwater and Soils http://www.epa.gov/osw/hazard/correctiveaction/eis/vapor/complete.pdf, using target risk levels of $1x10^{-6}$ excess lifetime cancer risk and noncancer hazard quotient of 0.1 in accordance with best practices for vapor intrusion screening to account fc cumulative effects from multiple chemicals. Values updated with Spring 2012 Regional Screening Levels (Residential Indoor Air) for Chemical Contaminants at Superfund Sites http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm.

-- = not applicable, no detections were reported during analysis of this sample.

Key:

BRL = below the reporting limit
DL = detection limit
EPA = United States Environmental Protection Agency
ft msl = feet mean sea level
GW-2 = MCP Method 1 GW-2 groundwater standard
MCP = Massachusetts Contingency Plan
MassDEP = Massachusetts Department of Environmental Protection
MW = monitoring well sample
RL = reporting limit
VI COPC = Vapor Intrusion Contaminant of Potential Concern
µg/L = micrograms per liter

APPENDIX D

CS-19 Vapor Intrusion Evaluation

TABLE OF CONTENTS

Figures

Tables

ACRONYMS AND ABBREVIATIONS

AFCEE	Air Force Center for Engineering and the Environment
CIA	Central Impact Area
COC	contaminant of concern
CS	Chemical Spill
CSM	conceptual site model
EPA	U.S. Environmental Protection Agency
ft	feet/foot
LUC	land use controls
LTM	long term monitoring
MassDEP	Massachusetts Department of Environmental Protection
MMR	Massachusetts Military Reservation
msl	mean sea level
RDX	hexahydro-1,3,5-trinitro-1,3,5-triazine
ROD	Record of Decision
USACE	U.S. Army Corps of Engineers
VI	vapor intrusion
μg/L	micrograms per liter

D1.0 CHEMICAL SPILL-19 VAPOR INTRUSION EVALUATION

D1.1 CS-19 CONCEPTUAL SITE MODEL

The Chemical Spill–19 (CS-19) groundwater plume is a dilute dissolved-phase groundwater plume located within the boundary of the Massachusetts Military Reservation (MMR) in Sandwich, Massachusetts (Figure 1-2 of the main document). The CS-19 plume is located in the Impact Area, near the larger Central Impact Area (CIA) groundwater plume (Figure D-1). The CIA plume is located upgradient, crossgradient, and beneath the CS-19 plume. The CS-19 plume is a separate and distinct plume and source area that is being addressed separately from the CIA plume. The CIA source area and plume are currently managed by the Army under the Impact Area Groundwater Study Program (AFCEE 2009c). The CS-19 plume (Figure D-1) is defined as the extent of groundwater containing the contaminant of concern (COC), hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX), at concentrations greater than the U.S. Environmental Protection Agency (EPA) calculated risk-based concentration of 0.6 micrograms per liter (µg/L) for CS-19 groundwater (AFCEE 2009a).

The primary source for the CS-19 plume was the historical disposal of ordnance at the CS-19 site. The Air Force Center for Engineering and the Environment (AFCEE) conducted remedial activities between 2004 and 2006, and between 2007 and 2009, including the excavation of the top 2 to 3 feet (ft) of soil and the removal of the associated munitions and explosives of concern (AFCEE 2009a,b). Based on confirmatory sampling, the EPA and the Massachusetts Department of Environmental Protection (MassDEP) agreed that the remaining RDX levels in soil are protective and that any RDX leaching to groundwater would be well below risk-based levels (AFCEE 2009a).

The current CS-19 plume is depicted as an elongated contiguous plume that is approximately 6,900 ft long, up to 550 ft wide, and up to 25 ft thick (Figures D-1 and D-2). Characteristic of all MMR groundwater plumes, the CS-19 plume descended in the aquifer as it migrated from its source area due to recharge accretion, resulting in the downgradient portions of the plume being located relatively deep in the aquifer and overlain by a lens of clean groundwater. A plan view of the CS-19 plume, along with the location of the line of cross-section and monitoring locations

used to support this vapor intrusion (VI) evaluation, are shown on Figure D-1. A cross-sectional view of the CS-19 plume is provided as Figure D-2.

The topography of the land above the CS-19 plume footprint is generally flat to the east but becomes more hummocky to the west due to the presence of the Buzzards Bay Moraine which is a north-south ridge of bouldery till overlying reworked drift deposits. The topography experiences a ground elevation change of approximately 70 ft within the footprint of the plume. Within the footprint of the plume, the maximum and minimum ground surface elevations are approximately 250 ft mean sea level (msl) and 180 ft msl, respectively (AFCEE 2009a).

The groundwater flow direction in the vicinity of the CS-19 plume is generally northwesterly and flow within the aquifer is primarily horizontal. The depth to groundwater in the vicinity of the CS-19 plume ranges from 120 to 200 ft below ground surface. The elevation of the water table is approximately 65 ft msl near the source area and approximately 55 ft msl at the leading edge of the plume. The aquifer saturated thickness in the CS-19 area is approximately 200 ft (AFCEE 2009a).

A Remedial Investigation at CS-19 (AFCEE 2003) concluded that the contaminated groundwater presents a low, but unacceptable, potential future risk to human receptors. An interim remedy of long term monitoring (LTM) for CS-19 groundwater was selected in 2005 and documented in the CS-19 Interim Record of Decision (ROD) (AFCEE 2006). The CS-19 Feasibility Study evaluated a range of remedial alternatives (AFCEE 2009c), and a Final CS-19 ROD was issued in 2009 (AFCEE 2009a). The selected remedy for the CS-19 plume consists of monitored natural attenuation of groundwater concentrations demonstrated through an LTM program and implementation of land use controls (LUC) to prevent residential exposure to the CS-19 groundwater contamination. As noted earlier, as a result of source area remedial activities, remaining RDX concentrations in soil are not expected to result in an ongoing source of contamination to CS-19 groundwater.

D1.2 STEP 1: CLEAN WATER LENS

As established in Section 4.1.1 and depicted graphically in Figure 4-1 of the main document, the first step in evaluating the possibility of VI for a groundwater plume is determining whether a continuous 3-ft-thick clean water lens is present above the entire plume and is expected to remain for the foreseeable future as long as the plume exists. If the evaluation indicates that a clean water lens is present using the criteria presented in Section 4.1.1 of the main document, it can be concluded that the VI pathway is incomplete and no further evaluation is required.

The clean water lens evaluation for the CS-19 plume included a review of available analytical data for the CS-19 COC, RDX. For this CS-19 VI evaluation, the absence of RDX detections in groundwater at or near the water table defines the presence of a clean water lens.

The following section evaluates the presence of a clean water lens for the CS-19 groundwater plume. The monitoring locations used for the CS-19 VI evaluation are shown on Figures D-1 and D-3. The most recent RDX data used to support this evaluation, and to illustrate the location of the RDX plume in the aquifer, are shown on the northwest-southeast cross-sectional depiction of the plume on Figure D-2. The supporting analytical data are summarized in Table D-1. The well construction and sampling location information used in this evaluation are included in Table D-2.

D1.2.1 CS-19 Groundwater Plume

As described in the conceptual site model (CSM) in Section D1.1, the most recent monitoring data indicate that the majority of the CS-19 plume is located relatively deep in the aquifer and is overlain by a substantial thickness of clean water well in excess of 3 ft. The data that support this aspect of the CSM are as follows:

- Groundwater vertical profile data collected in 2000 and 2001 at sample elevations above the CS-19 plume along the axis of the plume at 58MW0018A, 58MW0020B, MW183, and MW201 indicate the presence of at least a 40 ft thickness of clean water above the CS-19 plume.

- Monitoring data collected between 2000 and 2010 from monitoring wells 58MW0020B (2010), MW183M2 (2009), MW201M3 (2005), and 58MW0018C (2000) screened above the CS-19 plume, in which RDX was not detected, were used to confirm the presence of a clean water lens.

However, the latest available monitoring data collected in 2010 and 2011 at wells located within the footprint of the source area (58MW0001, 58MW0002, and 58MW0016C), which are all screened at or near the water table, indicate that detectable concentrations of RDX remain. (Figure D-2 and Table D-1). Therefore, based on these data, a clean water lens cannot be demonstrated to exist over the entire plume and an incomplete VI pathway cannot be confirmed; further VI evaluation (i.e., Step 2 of the VI evaluation process) is warranted for the area below and immediately downgradient of the CS-19 source area (Figure D-3).

D1.3 STEP 2: BUILDINGS AND PREFERENTIAL AIRFLOW PATHWAYS

If it is determined that a constant 3-ft lens of clean water does not exist or its presence cannot be demonstrated with an adequate level of certainty, the next step in a VI assessment is the evaluation of the proximity of potential receptors (Section 4.1.2 of main text). This is only necessary for the portion of the plume between the source area and immediately downgradient (Figure D-3).

D1.3.1 Source Area

As noted above, the extent of RDX detections in CS-19 monitoring wells screened at or near the water table is limited to three wells (58MW0001, 58MW0002, and 58MW0016C) that are located within the footprint of the source area. Note that the extent of groundwater contamination at the water table in the source area is defined by no detections of RDX at 58MW0003, 58MW0004, 58MW0005E, 58MW0006E, and 58MW0015B located to the north and east of the source area (Figure D-3). No monitoring wells exist to the south of the source area; however, given the understanding of the nature of the source area releases, the soil remedial actions, and the groundwater flow field, this characterization uncertainty is acceptable for this VI evaluation. Although the northwestern extent of the water table RDX detections is also not well defined near the source area, as discussed above, a 40 ft thick clean water lens exists approximately 2,300 ft northwest of the source area at 58MW0018A (Figure D-3). There are no

existing buildings located within at least 1,000 ft of the three above-mentioned shallow monitoring wells with RDX detections. This distance greatly exceeds the 100 ft criterion specified in Section 4.1.2 of the main document. In addition, based on information provided by the base 102nd Civil Engineering Squadron, there are no known underground utilities that could act as preferential airflow pathways within 100 ft of these CS-19 source area wells (Department of the Air Force 2012).

The land above the CS-19 source area is presently inactive for military purposes, although the land use at the Impact Area is still considered military use and is in a restricted area surrounded by fencing and guarded gates. Since the CS-19 source area is located within the MMR, future development, including the construction of new buildings in this area, is controlled through institutional controls specified in the CS-19 ROD (AFCEE 2009a). Specifically, the Air National Guard has administrative processes and procedures that require approval for all projects involving construction or digging/subsurface soil disturbance at the MMR. In the event construction activities were planned in the CS-19 source area, the Installation Restoration Program would take appropriate measures to address VI concerns as they relate to any future structures and/or underground utilities or other potential preferential airflow pathways.

D2.0 CONCLUSIONS AND RECOMMENDATIONS

D2.1 CONCLUSIONS

A review of groundwater characterization and monitoring data collected at CS-19 indicates that a continuous clean water lens at least 3 ft thick is present above the majority of the CS-19 plume and is expected to be present in the future as long as the plume exists. However, residual RDX concentrations are present at the water table below and near the CS-19 source area. Although a clean water lens does not exist below the CS-19 source area (thus a clean water lens does not overlie the entire CS-19 plume), no buildings or preferential airflow pathways are located in this area and future site development is controlled by on-base entities. Therefore, the VI exposure pathway at CS-19 is considered insignificant due to the absence of nearby receptors.

D2.2 RECOMMENDATIONS

No further monitoring or data collection is needed specific to VI. However, as part of the ongoing LTM program at CS-19, AFCEE will continue to monitor the extent and attenuation of the CS-19 plume. The VI exposure pathway will be re-evaluated if conditions change such that VI could become a concern.

D3.0 REFERENCES

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FIGURE D-1

CS-19 GROUNDWATER PLUME AND LOCATION OF CROSS-SECTION LINES

AFCEE - Massachusetts Military Reservation

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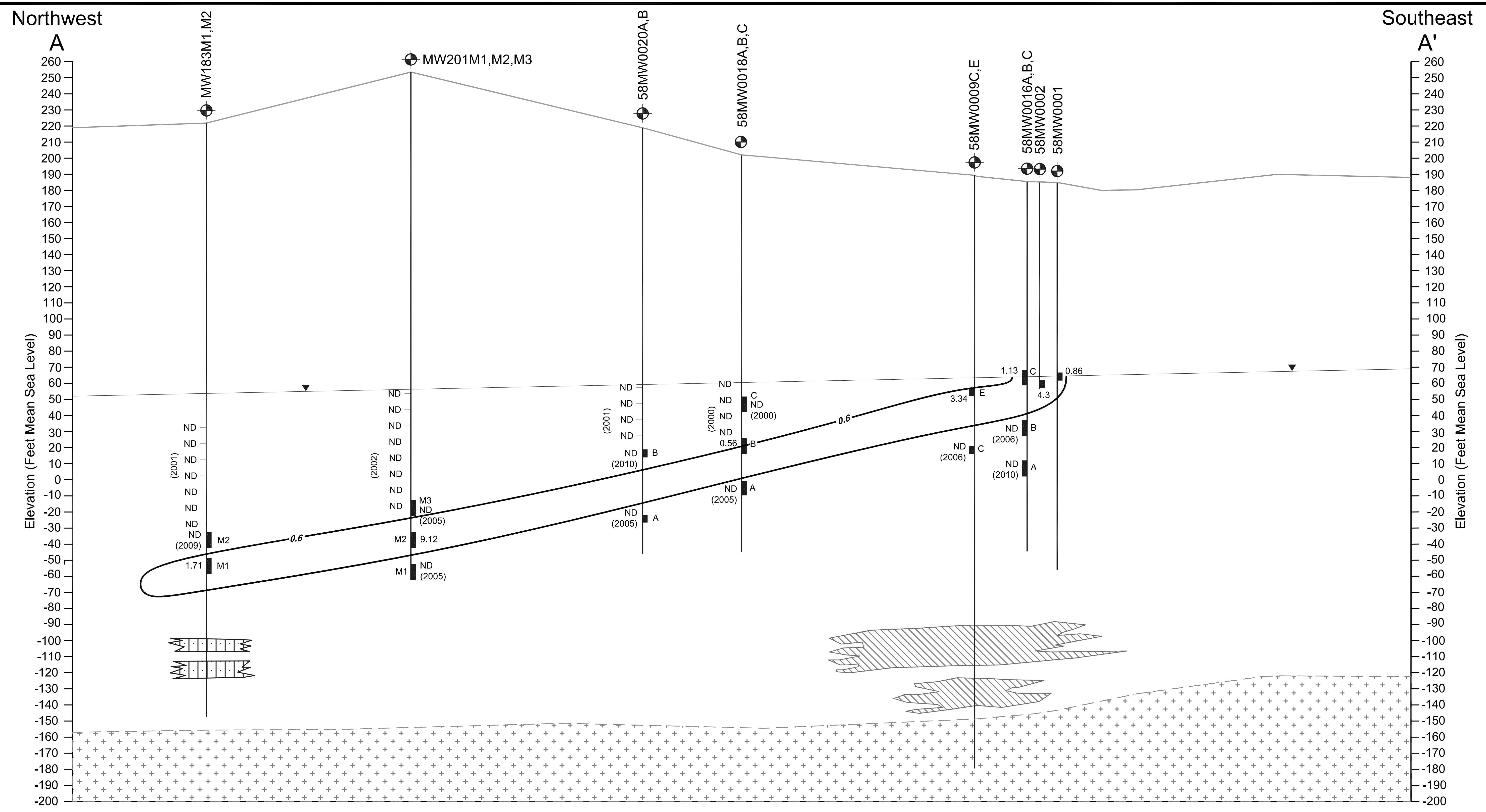

Legend

- Monitoring Well
- Water Table
- A — Well Screen ID
- CS-19 Plume Boundary
- 3.5 — RDX Data (µg/L) Collected in 2011 Unless Otherwise Noted
- (2001) ND — RDX Vertical Profile Data (µg/L) (Date Collected)
- ND — Not Detected
- Silty Sand
- Silty Clay
- Bedrock

Data Source: AFCEE, April 2012, AFCEE-MMR Data Warehouse and EDMS (Army Database)

Note: 1. Vertical profile data collected from the shallowest intervals are shown to support this vapor intrusion clean water lens evaluation.

0 Feet

V: 60
H: 750

FIGURE D-2

CS-19 CROSS-SECTION A-A'

AFCEE - Massachusetts Military Reservation

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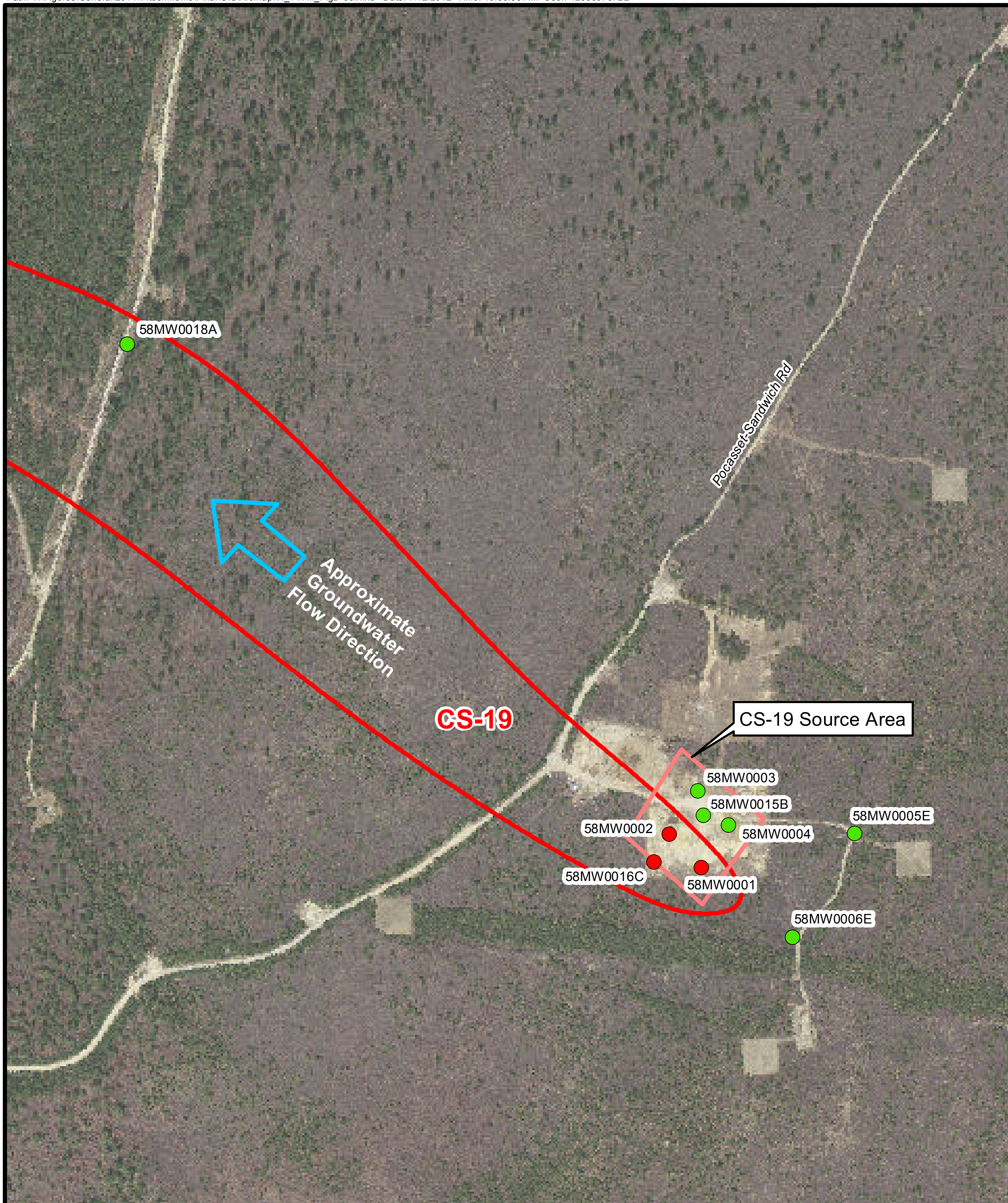

Legend

- Monitoring Well - VI COPC Detected
- Monitoring Well - VI COPC Not Detected
- Plume Boundary
- Plume Source Area Boundary

Data Source: AFCEE, MMR-AFCEE Data Warehouse
2009 Aerial Photography from MassGIS

N

0 200 400 Feet

FIGURE D-3

EXTENT OF WATER TABLE VI COPC DETECTIONS AT CS-19

AFCEE - Massachusetts Military Reservation

Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

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Table D-1
CS-19 Groundwater Data Used in Support of VI Evaluation
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Location ID	Date Sampled	Mid-Sample Elevation (ft msl)	Sampling Method[1]	VI COPC[2]	Result (µg/L)
58MW0001	3/31/2011	59.19	MW	RDX	0.86
58MW0002	3/31/2011	59.42	MW	RDX	4.3
58MW0003	12/19/2005	62.26	MW	RDX	ND
58MW0004	1/20/2006	58.41	MW	RDX	ND
58MW0005E	3/3/2000	64.62	MW	RDX	ND
58MW0006E	12/30/2005	65.28	MW	RDX	ND
58MW0009E	4/4/2011	53.43	MW	RDX	3.34
58MW0015B	1/20/2006	49.4	MW	RDX	ND
58MW0016C	4/4/2011	63.5	MW	RDX	1.13
58MW0018A	2/25/2000	59.55	VP	RDX	ND
58MW0018A	2/25/2000	49.55	VP	RDX	ND
58MW0018A	2/25/2000	39.55	VP	RDX	ND
58MW0018A	2/28/2000	29.55	VP	RDX	ND
58MW0018C	3/20/2000	46.94	MW	RDX	ND
58MW0020B	8/6/2001	57.41	VP	RDX	ND
58MW0020B	8/6/2001	47.41	VP	RDX	ND
58MW0020B	8/6/2001	37.41	VP	RDX	ND
58MW0020B	8/6/2001	27.41	VP	RDX	ND
58MW0020B	2/23/2010	16.41	MW	RDX	ND
MW-183*	9/24/2001	32.47	VP	RDX	ND
MW-183*	9/24/2001	22.47	VP	RDX	ND
MW-183*	9/25/2001	12.47	VP	RDX	ND
MW-183*	9/25/2001	2.47	VP	RDX	ND
MW-183*	9/25/2001	-7.53	VP	RDX	ND
MW-183*	9/25/2001	-17.53	VP	RDX	ND
MW-183*	9/26/2001	-27.53	VP	RDX	ND
MW-183M2	12/28/2009	-37.59	MW	RDX	ND
MW-201*	1/15/2002	48.56	VP	RDX	ND
MW-201*	1/15/2002	38.56	VP	RDX	ND
MW-201*	1/15/2002	28.56	VP	RDX	ND
MW-201*	1/15/2002	18.56	VP	RDX	ND
MW-201*	1/15/2002	8.56	VP	RDX	ND
MW-201*	1/15/2002	-1.44	VP	RDX	ND
MW-201*	1/16/2002	-11.44	VP	RDX	ND

Table D-1
CS-19 Groundwater Data Used in Support of VI Evaluation
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Location ID	Date Sampled	Mid-Sample Elevation (ft msl)	Sampling Method[1]	VI COPC[2]	Result (µg/L)
MW-201*	1/16/2002	-21.44	VP	RDX	ND
MW-201M3	12/20/2005	-17.44	MW	RDX	ND

Data Source: AFCEE, May 2012, MMR-AFCEE Data Warehouse

Notes:

1. Sample collection methodology:
   VP = vertical profile groundwater sampling (direct push, rotosonic, or screened hollow-stem auger drilling methods)
   MW = fixed monitoring well

2. See Table 4-1 of the main document for a complete list of VI COPCs.

* Location ID is for groundwater vertical profiling data collected by the Army during advancement of this boring. Fixed monitoring wells that were installed subsequent to vertical profiling are designated with an M1, M2, or M3.

The data summarized in this table specifically support the CS-19 clean water lens VI evaluation and typically include the most recent sampling results for each location for the plume-related VI COPCs only. If additional historic sampling data exist, they are available for review in the AFCEE-MMR Data Warehouse.

Vertical profile data presented only include the relevant sample intervals used to support this CS-19 VI evaluation; if analytical data from deeper sample intervals exist, they are available in the AFCEE MMR Data Warehouse.

Key:

BRL = below reporting limit
COPC = contaminant of potential concern
CS-19 = Chemical Spill-19
ft msl = feet mean sea level
ND = not detected
RDX = Hexahydro-1,3,5-trinitro-1,3,5-triazine
VI = vapor intrusion
µg/L = micrograms per liter

Table D-2
CS-19 Well Construction and Sample Location Information
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Location	Northing (ft)	Easting (ft)	Surface Elevation (ft msl)	Measuring Point Elevation (ft msl)	Total Well Depth (ft bgs)	Top Screen Depth (ft bgs)	Bottom Screen Depth (ft bgs)	Top Screen Elevation (ft msl)	Bottom Screen Elevation (ft msl)	Screen Length (ft)
58MW0001	260764	860693	183	183.18	127	121.80	126.80	61.69	56.69	5
58MW0002	260864	860599	183	182.86	126.5	121.20	126.20	61.92	56.92	5
58MW0003	260994	860683	184	183.76	124.1	119.00	124.00	64.76	59.76	5
58MW0004	260891	860775	183	182.87	127.5	122.30	127.30	60.91	55.91	5
58MW0005E	260866	861153	185	186.16	125	115.00	125.00	69.62	59.62	10
58MW0006E	260555	860966	180	181.93	119.6	109.60	119.60	70.28	60.28	10
58MW0009E	261047	860243	189	191.73	138	133.40	138.40	55.93	50.93	5
58MW0015B	260919	860700	185	187.15	140	130.96	140.22	54.03	44.77	9
58MW0016C	260781	860553	185	187.29	127	116.70	126.33	68.32	58.69	10
58MW0018A	262328	858977	202	204.61	212	202.70	211.70	-0.65	-9.65	10
58MW0018C	262340	858981	202	204.20	160	149.92	159.60	51.78	42.10	10
58MW0020B	262627	858267	219	221.73	205	200.00	205.00	18.91	13.91	5
MW-183M2	263975	855235	237	236.83	280	270.00	280.00	-32.59	-42.59	10
MW-183*	263980	855237	237	NA	NA	NA	NA	NA	NA	NA
MW-201M3	263244	856577	254	255.11	276	266.00	276.00	-12.44	-22.44	10
MW-201*	263243	856576	254	NA	NA	NA	NA	NA	NA	NA

Data Source: AFCEE, May 2012, MMR-AFCEE Data Warehouse

Note:

* Location ID represents the boring at which groundwater vertical profiling data was collected by the Army during advancement. Fixed monitoring wells that were installed subsequent to vertical profiling are designated with an M1, M2, or M3.

Key:

bgs = below ground surface

CS-19 = Chemical Spill-19

ft = feet

msl = mean sea level

NA = data not available; locations are vertical profile borings.

APPENDIX E

CS-20 Vapor Intrusion Evaluation

TABLE OF CONTENTS

Figures

Tables

ACRONYMS AND ABBREVIATIONS

AFCEE	Air Force Center for Engineering and the Environment
bgs	below ground surface
COC	contaminant of concern
CS	Chemical Spill
CSM	Conceptual Site Model
FS	Fuel Spill
ft	feet/foot
gpm	gallons per minute
HATF	Hunter Avenue Treatment Facility
MCL	Maximum Contaminant Level
MMR	Massachusetts Military Reservation
msl	mean sea level
PCE	tetrachloroethene
RI	Remedial Investigation
SPEIM	System Performance and Ecological Impact Monitoring
VI	vapor intrusion
VOC	volatile organic compound
µg/L	micrograms per liter

E1.0 CHEMICAL SPILL-20 VAPOR INTRUSION EVALUATION

E1.1 CS-20 CONCEPTUAL SITE MODEL

The Chemical Spill–20 (CS-20) groundwater plume is a dilute dissolved-phase groundwater plume located south of the Massachusetts Military Reservation (MMR) in Falmouth, Massachusetts (Figure 1-2 of main document), which is detached from its source area. The CS-20 plume (Figure E-1) is currently defined as the extent of groundwater containing the contaminant of concern (COC), tetrachloroethene (PCE), at concentrations greater than the Maximum Contaminant Level (MCL) of 5 micrograms per liter (µg/L).

The CS-20 plume was first detected in 1997 during the Fuel Spill-28 (FS-28) Remedial Investigation (RI) drilling program, and was further defined during the Southwest Operable Unit RI (AFCEE 1999). Although the specific source of the CS-20 plume has not been identified, potential source areas located hydraulically upgradient of the CS-20 plume were investigated and remediated (if needed) through the Installation Restoration Program in accordance with the established regulatory framework for the MMR sites (AFCEE 2008a, 2008b).

A plan view of the CS-20 plume, along with the location of the line of cross-section and monitoring locations used to support this vapor intrusion (VI) evaluation, are shown on Figure E-2. A cross-sectional view of the CS-20 PCE plume is provided as Figure E-3.

Based on the most recent depiction of the CS-20 plume boundary, the plume extends from just south of Kittredge Road near the southern MMR base boundary approximately 8,300 feet (ft) below Route 151 and Boxberry Hill Road nearly to the northwest corner of Deep Pond. The CS-20 plume has a maximum width of approximately 1,000 ft (Figure E-2). Characteristic of many of the MMR groundwater plumes, the CS-20 plume descended in the aquifer as it migrated from its source area due to recharge accretion, which has resulted in the plume being located relatively deep in the aquifer and entirely overlain by a lens of clean groundwater. The CS-20 plume is up to approximately 75 ft thick in the aquifer and the upper boundary of the plume is between approximately 60 and 160 ft below ground surface (bgs) and between 40 and 120 ft below the water table (Figure E-3). The depiction of the plume shown in cross-sectional view on

Figure E-3 is based on data collected in 2011, whereas the plume boundary shown on Figures E-1 and E-2 is based on data collected in 2010.

The topography of the land above the CS-20 plume footprint is generally flat with a ground elevation change of approximately 20 to 30 ft from north to south. Sub-regionally, the area is characterized by low rolling hills and flat areas of the Mashpee Pitted Plain, which is a broad, flat, gently southward-sloping glacial outwash plain (AFCEE 2000). Within the footprint of the plume, the maximum and minimum ground surface elevations are approximately 108 ft mean sea level (msl), and 46 ft msl, respectively.

The groundwater flow direction in the vicinity of the CS-20 plume is generally to the southwest and flow within the aquifer is primarily horizontal. The depth to groundwater above the CS-20 plume ranges from approximately 20 to 80 ft bgs; the elevation of the water table within the CS-20 area ranges from approximately 37 ft msl in the southwest leading edge near Deep Pond to 55 ft msl near the northeast portion of the plume. The aquifer saturated thickness in the CS-20 area ranges from approximately 200 to 250 ft.

The Air Force Center for Engineering and the Environment (AFCEE) issued a Record of Decision in 2000 which specified design and construction of a treatment system to address the CS-20 plume (AFCEE 2000). Due to difficulties achieving access to an acceptable location in which to install an originally-designed third CS-20 extraction well (81EW0003), AFCEE decided to forego its construction and instead perform monitoring in the plume's leading edge area. An Explanation of Significant Differences for CS-20 was issued in September 2008 to document the final design of the treatment system, which includes the two extraction well system, and natural attenuation for the leading edge portion of the plume as part of the final remedy (AFCEE 2008b).

The CS-20 remedial system consists of two extraction wells (81EW0001 and 81EW0002) and is part of the Southwest Plumes remedial system (Figure E-1), which was designed to collectively remediate the CS-4, CS-20, CS-21, and FS-29 groundwater plumes (Figure E-1). The contaminated groundwater is captured by extraction wells in each plume and treated at a centrally located treatment plant, the Hunter Avenue Treatment Facility (HATF). The flow from

the CS-4 and CS-20 extraction wells is combined, enters the HATF through a common influent line, and is treated through a series of granular activated carbon vessels. Likewise, the flow from the CS-21 (and formerly from the FS-29 extraction wells when the FS-29 wells were operational prior to September 2010) enters the HATF through a common influent line; this water is treated through a second granular activated carbon treatment train. The treated water from the CS-4/CS-20 and CS-21 treatment trains exits the HATF in a combined effluent line and all treated water is returned to the aquifer through reinjection wells, an infiltration trench, and an infiltration gallery (AFCEE 2011).

The two CS-20 extraction wells became operational in January 2006 at a total flow rate of 775 gallons per minute (gpm). As a result of a June 2010 optimization, the two CS-20 extraction wells are currently operating at a combined flow rate of 749 gpm. The most recent transport model simulations predict that the CS-20 extraction wells can be turned off by approximately 2017, and PCE concentrations throughout the CS-20 plume are expected to decline below the MCL through natural attenuation by approximately 2023 (AFCEE 2012).

E1.2 STEP 1: CLEAN WATER LENS

As established in Section 4.1.1 and depicted graphically in Figure 4-1 of the main document, the first step in evaluating the possibility of VI for a groundwater plume is determining whether a continuous 3-ft-thick clean water lens is present above the entire plume and is expected to remain for the foreseeable future as long as the plume exists. If so, it can be concluded that the VI pathway is incomplete and no further evaluation is required.

The clean water lens evaluation included a review of the analytical data for the CS-20 COC (PCE), as well as other plume-related volatile organic compounds (VOCs) included in the list of VI contaminants of potential concern in Table 4-1 of the main document. For this CS-20 VI evaluation, the absence of plume-related VOC detections in groundwater in the portion of the aquifer above the plume footprint will define the presence of clean water. The locations of all the monitoring points used for this VI evaluation are shown on Figure E-2. The most recent PCE data used to support this evaluation, and to illustrate the location of the plume in the aquifer, are shown on the northeast-southwest cross-sectional depiction of the CS-20 plume on Figure E-3,

and the analytical data are summarized in Table E-1. The well construction and sampling location information used in this evaluation are included in Table E-2.

As described in the conceptual site model (CSM) in Section E1.1, the most recent monitoring data indicate that the CS-20 plume is located deep in the aquifer. In addition, historic characterization data collected during the RI (AFCEE 1999) and the pre-remedial system design investigation (AFCEE 2003), as well as recent data collected under the System Performance and Ecological Impact Monitoring (SPEIM) program, confirm that the CS-20 plume is overlain by a substantial thickness of clean water well in excess of 3 ft. The data that support this aspect of the CSM are as follows and are presented on Figure E-2, Figure E-3, and in Table E-1:

- Groundwater vertical profile data collected for a 2011 remedial system optimization evaluation at direct push drilling locations 81DP1010, 81DP1011, 81DP1012, and 81DP1013 indicate the presence of over 50 ft of clean water above the CS-20 plume.
- Groundwater vertical profile data collected at sample elevations above the CS-20 plume during rotosonic drilling at 81MW0018A and 81MW0019A in 2006 and 2008, respectively, confirm the presence of at least a 10 ft thickness of clean water above the CS-20 plume. These locations are hydraulically downgradient of the CS-20 extraction wells and therefore provide evidence of a clean water lens above the uncaptured leading edge portion of the plume.
- Groundwater vertical profile data collected at sample elevations above the CS-20 plume during rotosonic drilling at 81MW0003A, 81MW0005A, 81MW0008A, 81MW0011A, 81MW0013A, and 81MW0015A in 2001 indicate the presence of at least a 10 ft thickness of clean water above the plume at that time. Monitoring wells 81MW0008A and 81MW0015A are now located just outside of the 2010 plume boundary; however, when installed in 2001, both were within the CS-20 plume footprint and therefore data from these locations are useful to support the concept of a clean water lens above the CS-20 plume as described in the CSM.
- Similarly, vertical profile data collected at 69MW1503A, 69MW1507, and 69MW1517A in 1998 indicate the presence of at least a 60 ft thickness of clean water above the plume at that time. Monitoring wells 69MW1503A and 69MW1507 are now located outside of the 2010 CS-20 plume boundary but were within the plume boundary when they were installed and the data support the overall concept of a clean water lens above the plume.
- Monitoring data collected at the following wells screened above the CS-20 plume were used to confirm the presence of a clean water lens: 69MW1517B (2011) and 32MW2003 (2009).

In summary, characterization and monitoring data from multiple locations throughout the area of the CS-20 plume confirm the presence of a clean water lens overlying the entire plume well in excess of the 3-ft thickness criterion used for this VI screening evaluation. It is acknowledged, however, that some of these characterization data are not recent (i.e., dating back to 1998 in some cases). But when combined with more recent data collected as recently as 2011 and the overall understanding of the hydrogeologic aspect of the CSM, they still provide sound lines of evidence that the CS-20 plume is located deep in the aquifer and is overlain by a substantial thickness of clean water. Furthermore, given the substantial thickness of clean water above the entire plume, the low concentrations and limited extent of the plume, and the ongoing remedial actions, a change in the clean water lens presence is not anticipated in the future.

E2.0 CONCLUSIONS AND RECOMMENDATIONS

E2.1 CONCLUSIONS

A review of groundwater characterization and monitoring data collected at CS-20 indicates that a continuous clean water lens at least 3 ft thick is present above the entire body of the CS-20 plume and is expected to be present in the future as long as the plume exists. As evidenced by data indicating the presence of a substantial clean water lens overlying the entire extent of the CS-20 plume, and the ongoing remedial actions, the VI exposure pathway at CS-20 is incomplete, and further evaluation of VI associated with the CS-20 plume is not necessary.

E2.2 RECOMMENDATIONS

No further monitoring or data collection is needed specific to VI. However, as part of the ongoing remedial actions at CS-20, AFCEE will continue to monitor the nature and extent of the CS-20 plume under the SPEIM program and will re-evaluate the VI exposure pathway if conditions change such that VI could become a concern.

E3.0 REFERENCES

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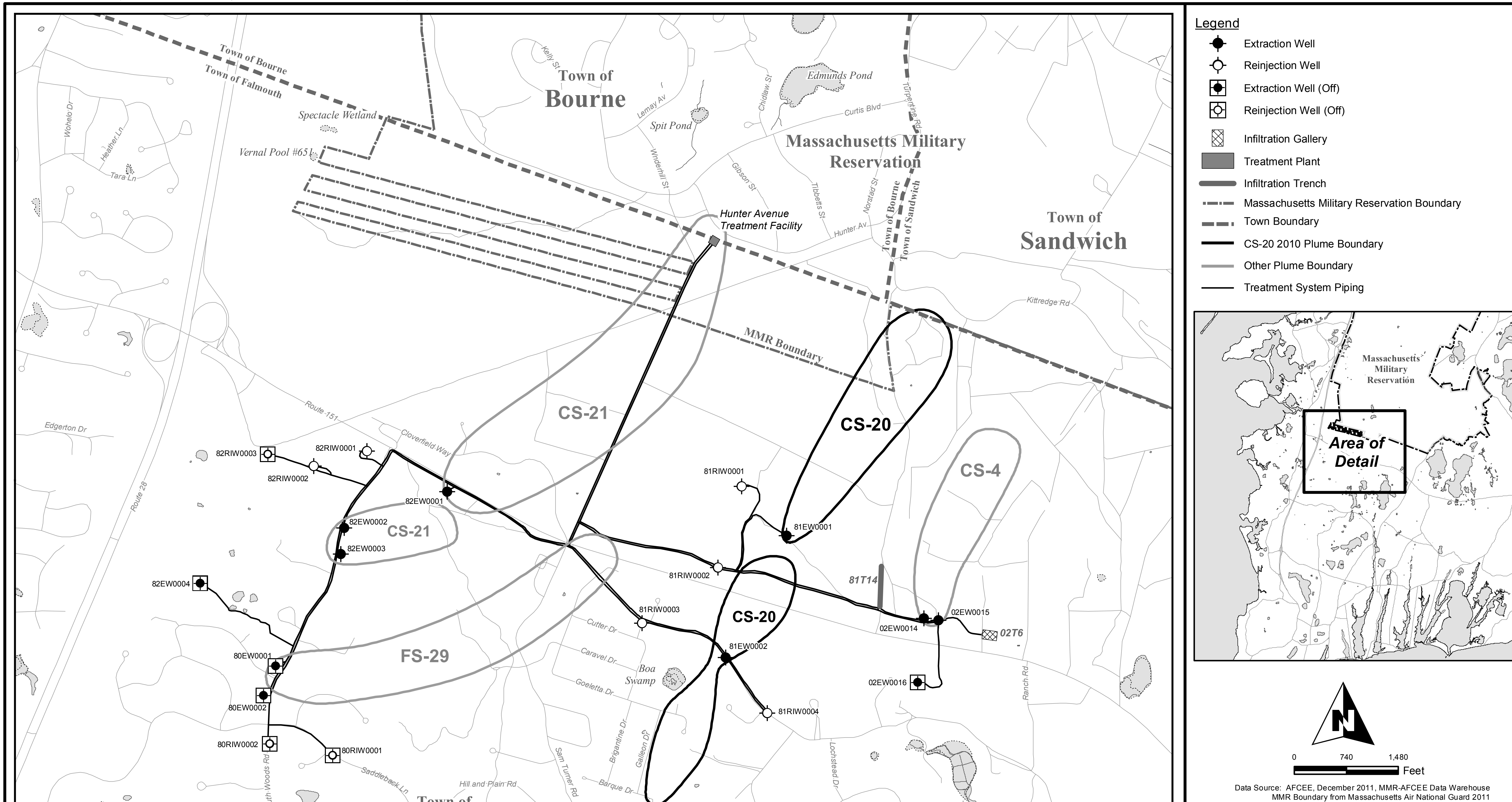

FIGURE E-1

CS-20 GROUNDWATER PLUME AND SOUTHWEST PLUMES REMEDIAL SYSTEM LAYOUT

AFCEE - Massachusetts Military Reservation

Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

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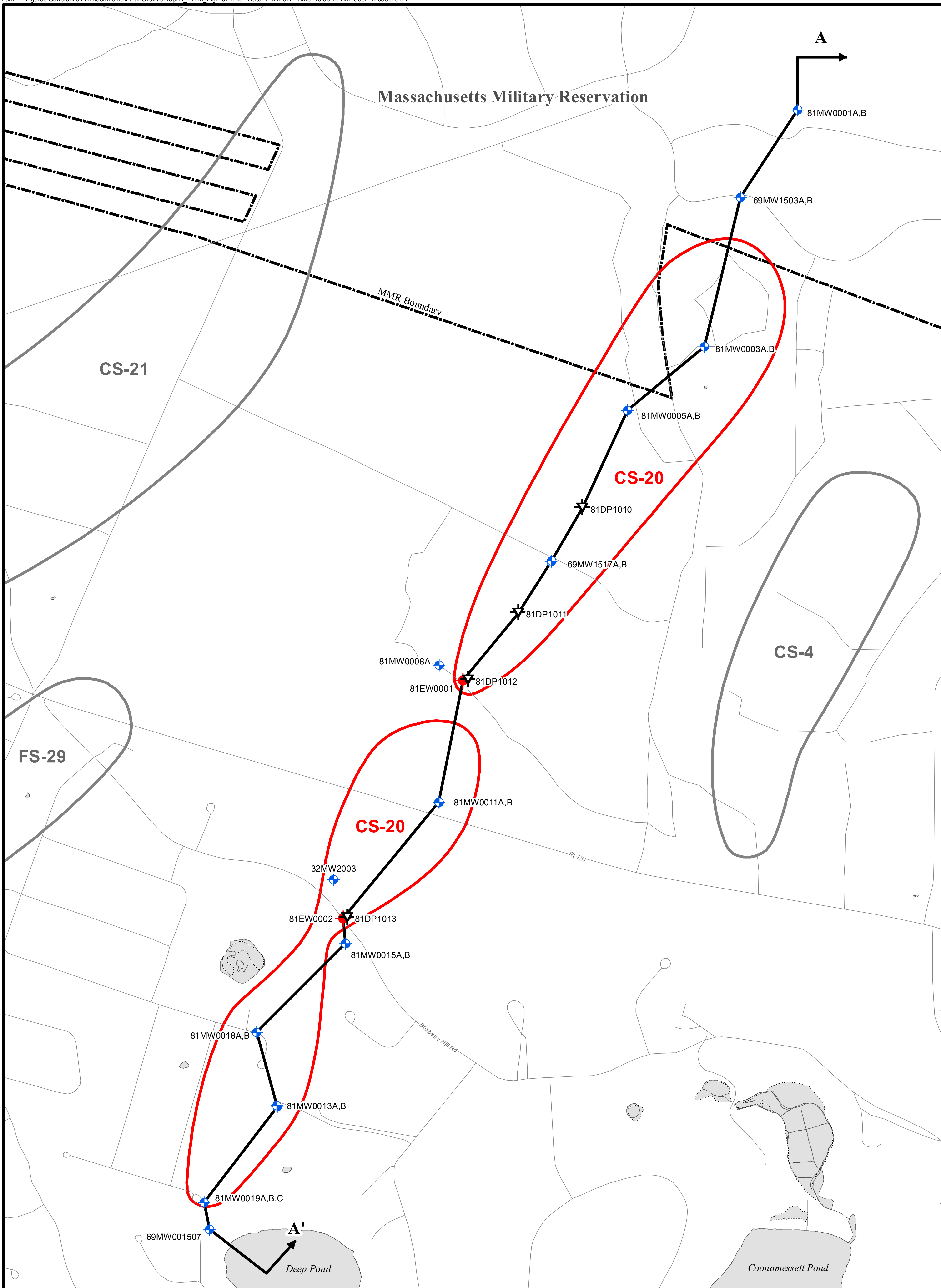

Legend

- Massachusetts Military Reservation Boundary
- 2010 CS-20 Plume Boundary
- Other Plume Boundary
- Bog/Wetland
- Extraction Well
- Monitoring Well
- Direct Push Location

Note: The plan view Southwest Plume boundaries will be updated following the 2012 triennial sample event.

Data Source: AFCEE, December 2011, MMR-AFCEE Data Warehouse, MMR Boundary from Massachusetts Air National Guard 2011

FIGURE E-2

CS-20 GROUNDWATER PLUME AND LOCATION OF CROSS-SECTION LINE

AFCEE - Massachusetts Military Reservation

Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

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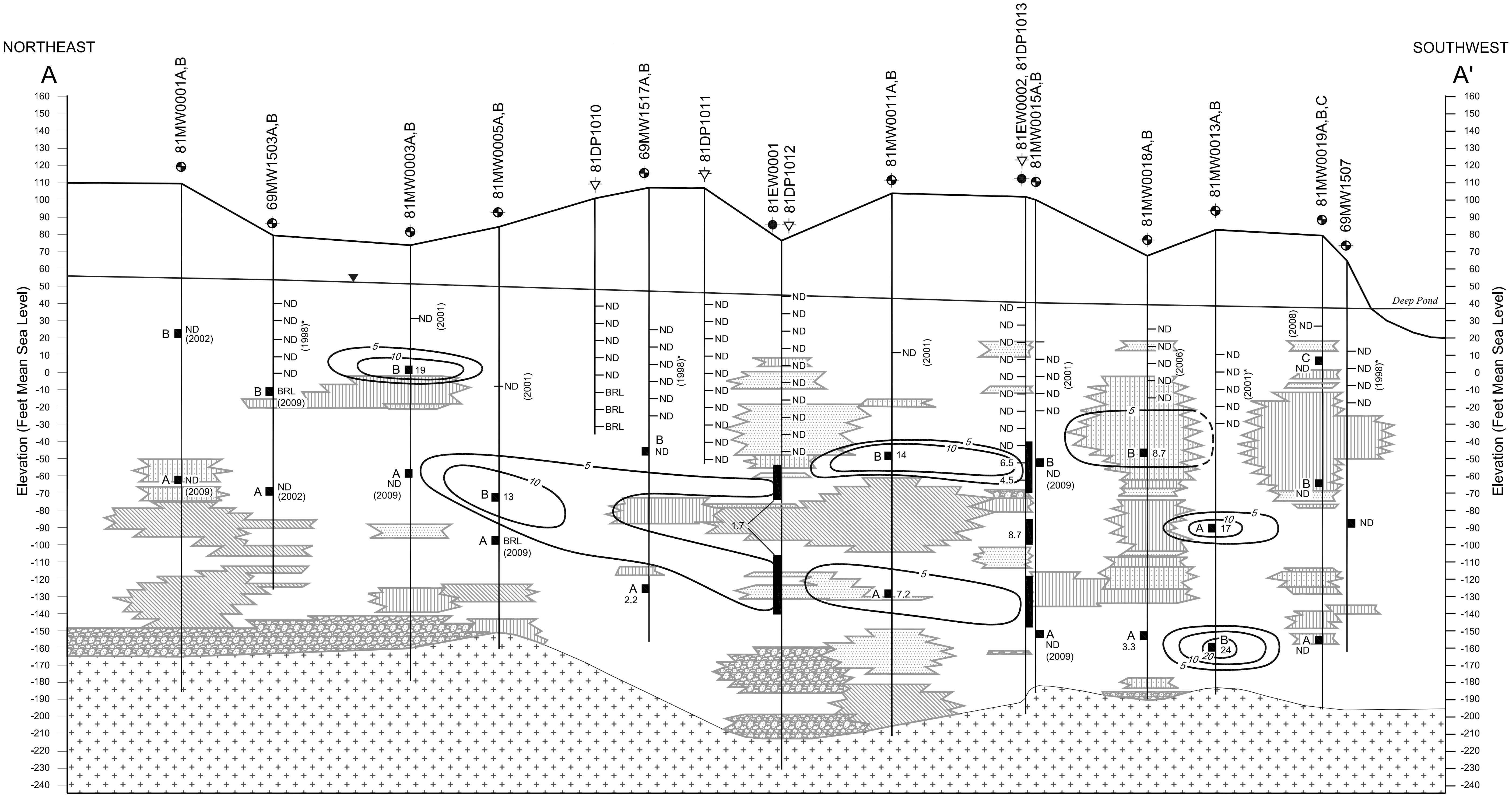

Legend

- Monitoring Well
- Extraction Well
- Water Table (05/2009)
- Direct Push Location

BRL Below Reporting Limit

ND Nondetect

2.2 PCE Data (µg/L) Collected in 2011 Unless Otherwise Noted

ND PCE Vertical Profile Data (µg/L) Collected in 2011 Unless Otherwise Noted

Extraction Well Screen

A Well Screen ID

—5— PCE Isoconcentration Contour (MCL = 5 µg/L) (Dashed Where Inferred)

Bedrock

Clay

Silt

Silty Sand

Fine Sand

Gravelly Sand

0 V: 60 H: 857 Feet

Data Source: AFCEE, December 2011, MMR-AFCEE Data Warehouse.

Notes:
1) This cross-section presents the most recent (2011 unless otherwise noted) data for CS-20 but does not correspond to the 2010 plume boundary presented on Figure E-2. The plan view Southwest Plume boundaries will be updated following the 2012 triennial sampling event.
2) *Vertical profile data collected in 1998 presented in Appendix G of the Final Southwest Operable Unit (SWOU) Remedial Investigation (AFCEE 1999).
3) Vertical profile data collected prior to 2011 from the shallowest intervals are shown to support the VI clean water lens evaluation.

FIGURE E-3

CS-20 CROSS-SECTION A - A'

AFCEE - Massachusetts Military Reservation

Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

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Table E-1
CS-20 Groundwater Data Used in Support of VI Evaluation
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Location	Date Sampled	Mid-Sample Elevation (ft msl)	Sampling Method[1]	Result[2]
32MW2003	5/18/2009	-3.83	MW	No detections of plume-related VI COPCs
69MW1503A	1/27/1998	40.00	VP	No detections of plume-related VI COPCs
69MW1503A	1/27/1998	30.00	VP	No detections of plume-related VI COPCs
69MW1503A	1/27/1998	19.00	VP	No detections of plume-related VI COPCs
69MW1503A	1/27/1998	9.00	VP	No detections of plume-related VI COPCs
69MW1503A	1/27/1998	0.00	VP	No detections of plume-related VI COPCs
69MW1507	2/25/1998	12.33	VP	No detections of plume-related VI COPCs
69MW1507	2/25/1998	2.33	VP	No detections of plume-related VI COPCs
69MW1507	2/25/1998	-7.67	VP	No detections of plume-related VI COPCs
69MW1507	2/25/1998	-17.67	VP	No detections of plume-related VI COPCs
69MW1507	2/26/1998	-57.67	VP	No detections of plume-related VI COPCs
69MW1507	2/26/1998	-67.67	VP	No detections of plume-related VI COPCs
69MW1507	2/26/1998	-77.67	VP	No detections of plume-related VI COPCs
69MW1507	2/27/1998	-87.67	VP	No detections of plume-related VI COPCs
69MW1507	2/27/1998	-97.67	VP	No detections of plume-related VI COPCs
69MW1507	2/27/1998	-107.67	VP	No detections of plume-related VI COPCs
69MW1507	2/27/1998	-117.67	VP	No detections of plume-related VI COPCs
69MW1507	2/27/1998	-127.67	VP	No detections of plume-related VI COPCs
69MW1507	3/2/1998	-157.67	VP	No detections of plume-related VI COPCs
69MW1517A	3/20/1998	24.70	VP	No detections of plume-related VI COPCs
69MW1517A	3/20/1998	14.70	VP	No detections of plume-related VI COPCs
69MW1517A	3/20/1998	4.70	VP	No detections of plume-related VI COPCs
69MW1517A	3/20/1998	-5.30	VP	No detections of plume-related VI COPCs
69MW1517A	3/20/1998	-15.30	VP	No detections of plume-related VI COPCs
69MW1517A	3/20/1998	-25.30	VP	No detections of plume-related VI COPCs
69MW1517B	3/24/2011	-45.78	MW	No detections of plume-related VI COPCs
81DP1010	2/9/2011	38.50	VP	No detections of plume-related VI COPCs
81DP1010	2/9/2011	28.50	VP	No detections of plume-related VI COPCs
81DP1010	2/9/2011	18.50	VP	No detections of plume-related VI COPCs
81DP1010	2/9/2011	8.50	VP	No detections of plume-related VI COPCs
81DP1010	2/11/2011	-1.50	VP	No detections of plume-related VI COPCs
81DP1011	2/16/2011	39.50	VP	No detections of plume-related VI COPCs
81DP1011	2/16/2011	29.50	VP	No detections of plume-related VI COPCs
81DP1011	2/16/2011	19.50	VP	No detections of plume-related VI COPCs
81DP1011	2/16/2011	9.50	VP	No detections of plume-related VI COPCs
81DP1011	2/16/2011	-0.50	VP	No detections of plume-related VI COPCs
81DP1011	2/17/2011	-10.50	VP	No detections of plume-related VI COPCs
81DP1011	2/17/2011	-20.50	VP	No detections of plume-related VI COPCs
81DP1011	2/17/2011	-30.50	VP	No detections of plume-related VI COPCs
81DP1011	2/17/2011	-40.50	VP	No detections of plume-related VI COPCs
81DP1011	2/17/2011	-50.30	VP	No detections of plume-related VI COPCs
81DP1012	2/24/2011	45.50	VP	No detections of plume-related VI COPCs
81DP1012	2/24/2011	35.50	VP	No detections of plume-related VI COPCs

Table E-1
CS-20 Groundwater Data Used in Support of VI Evaluation
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Location	Date Sampled	Mid-Sample Elevation (ft msl)	Sampling Method[1]	Result[2]
81DP1012	2/24/2011	25.50	VP	No detections of plume-related VI COPCs
81DP1012	2/24/2011	15.50	VP	No detections of plume-related VI COPCs
81DP1012	2/24/2011	5.50	VP	No detections of plume-related VI COPCs
81DP1012	2/24/2011	-4.50	VP	No detections of plume-related VI COPCs
81DP1012	2/24/2011	-14.50	VP	No detections of plume-related VI COPCs
81DP1012	2/24/2011	-24.50	VP	No detections of plume-related VI COPCs
81DP1012	2/25/2011	-34.50	VP	No detections of plume-related VI COPCs
81DP1012	2/25/2011	-44.50	VP	No detections of plume-related VI COPCs
81DP1013	3/3/2011	37.50	VP	No detections of plume-related VI COPCs
81DP1013	3/3/2011	27.50	VP	No detections of plume-related VI COPCs
81DP1013	3/3/2011	17.50	VP	No detections of plume-related VI COPCs
81DP1013	3/3/2011	7.50	VP	No detections of plume-related VI COPCs
81DP1013	3/3/2011	-2.50	VP	No detections of plume-related VI COPCs
81DP1013	3/4/2011	-12.50	VP	No detections of plume-related VI COPCs
81DP1013	3/4/2011	-22.50	VP	No detections of plume-related VI COPCs
81DP1013	3/4/2011	-32.50	VP	No detections of plume-related VI COPCs
81DP1013	3/4/2011	-42.50	VP	No detections of plume-related VI COPCs
81MW0003A	3/9/2001	31.31	VP	No detections of plume-related VI COPCs
81MW0005A	3/14/2001	-8.00	VP	No detections of plume-related VI COPCs
81MW0008A	2/27/2001	-14.76	VP	No detections of plume-related VI COPCs
81MW0008A	2/28/2001	-24.76	VP	No detections of plume-related VI COPCs
81MW0008A	2/28/2001	-34.76	VP	No detections of plume-related VI COPCs
81MW0008A	2/28/2001	-44.76	VP	No detections of plume-related VI COPCs
81MW0008A	2/28/2001	-54.76	VP	No detections of plume-related VI COPCs
81MW0008A	2/28/2001	-64.76	VP	No detections of plume-related VI COPCs
81MW0008A	2/28/2001	-74.76	VP	No detections of plume-related VI COPCs
81MW0008A	3/1/2001	-84.76	VP	No detections of plume-related VI COPCs
81MW0008A	3/1/2001	-94.76	VP	No detections of plume-related VI COPCs
81MW0008A	3/1/2001	-104.76	VP	No detections of plume-related VI COPCs
81MW0011A	5/5/2001	11.40	VP	No detections of plume-related VI COPCs
81MW0013A	6/18/2001	10.25	VP	No detections of plume-related VI COPCs
81MW0013A	6/19/2001	0.25	VP	No detections of plume-related VI COPCs
81MW0013A	6/19/2001	-9.75	VP	No detections of plume-related VI COPCs
81MW0013A	6/19/2001	-19.75	VP	No detections of plume-related VI COPCs
81MW0013A	6/19/2001	-29.75	VP	No detections of plume-related VI COPCs
81MW0015A	9/27/2001	17.66	VP	No detections of plume-related VI COPCs
81MW0015A	9/27/2001	7.66	VP	No detections of plume-related VI COPCs
81MW0015A	9/27/2001	-2.34	VP	No detections of plume-related VI COPCs
81MW0015A	9/27/2001	-12.34	VP	No detections of plume-related VI COPCs
81MW0015A	9/27/2001	-22.34	VP	No detections of plume-related VI COPCs
81MW0018A	2/6/2006	25.26	VP	No detections of plume-related VI COPCs
81MW0018A	2/6/2006	15.26	VP	No detections of plume-related VI COPCs
81MW0018A	2/7/2006	5.26	VP	No detections of plume-related VI COPCs

Table E-1
CS-20 Groundwater Data Used in Support of VI Evaluation
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Location	Date Sampled	Mid-Sample Elevation (ft msl)	Sampling Method[1]	Result[2]
81MW0018A	2/7/2006	-4.74	VP	No detections of plume-related VI COPCs
81MW0018A	2/7/2006	-14.74	VP	No detections of plume-related VI COPCs
81MW0019A	10/7/2008	26.89	VP	No detections of plume-related VI COPCs

Data Source: AFCEE, December 2011, MMR-AFCEE Data Warehouse

Notes:
1. Sample collection methodology:
   VP = vertical profile groundwater sampling (direct push, rotosonic, or screened hollow-stem auger drilling methods)
   MW = fixed monitoring well

2. See Table 4-1 of the main document for a complete list of VI COPCs.

The data summarized in this table specifically support the CS-20 clean water lens VI evaluation and typically include the most recent sampling results for each location for the plume-related VI COPCs only. If additional historic sampling data exist, they are available for review in the AFCEE-MMR Data Warehouse.

Vertical profile data presented only includes the relevant sample intervals used to support this CS-20 VI evaluation; if analytical data from deeper sample intervals exist, they are available in the AFCEE MMR Data Warehouse.

Key:
COPC = contaminant of potential concern
CS-20 = Chemical Spill-20
ft msl = feet mean sea level
VI = vapor intrusion

Table E-2
CS-20 Well Construction and Sample Location Information
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Location	Northing (ft)	Easting (ft)	Surface Elevation (ft msl)	Measuring Point Elevation (ft msl)	Total Well Depth (ft bgs)	Top Screen Depth (ft bgs)	Bottom Screen Depth (ft bgs)	Top Screen Elevation (ft msl)	Bottom Screen Elevation (ft msl)	Screen Length (ft)
32MW2003	231808	852193	99	98.24	105	100.00	105.00	-1.33	-6.33	5
69MW1503A	236782	855160	80	80.75	151	146.00	151.00	-66.50	-71.50	5
69MW1507	229258	851288	65	67.27	155	149.90	154.90	-85.07	-90.07	5
69MW1517A	234126	853780	107	109.13	236	230.20	235.20	-123.00	-128.00	5
69MW1517B	234133	853782	107	109.28	156	150.50	155.50	-43.28	-48.28	5
81DP1010	234516	854006	101	-	-	NA	NA	NA	NA	NA
81DP1011	233750	853537	107	-	-	NA	NA	NA	NA	NA
81DP1012	233261	853171	78	-	-	NA	NA	NA	NA	NA
81DP1013	231530	852291	100	-	-	NA	NA	NA	NA	NA
81MW0003A	235694	854897	74	73.35	135	129.91	134.91	-56.10	-61.10	5
81MW0005A	235230	854337	85	84.10	185	179.50	184.50	-95.00	-100.00	5
81MW0008A	233373	852962	78	77.59	246	240.00	245.00	-162.26	-167.26	5
81MW0011A	232371	852960	104	103.39	235	229.89	234.65	-125.99	-130.75	5
81MW0013A	230153	851780	83	82.91	175	169.85	174.96	-87.10	-92.21	5
81MW0015A	231343	852280	100	99.88	255	249.59	254.28	-149.43	-154.12	5
81MW0018A	230694	851633	68	67.51	224	218.00	223.00	-150.24	-155.24	5
81MW0019A	229456	851248	79	79.18	237	232.44	236.95	-153.05	-157.56	5

Data Source: AFCEE, December 2011, MMR-AFCEE Data Warehouse

Key:
bgs = below ground surface
CS-20 = Chemical Spill-20
ft = feet
msl = mean sea level
NA = data not available; locations are direct push vertical profile locations and have no screen information.

APPENDIX F

CS-21 Vapor Intrusion Evaluation

TABLE OF CONTENTS

Figures

Tables

ACRONYMS AND ABBEVIATIONS

AFCEE	Air Force Center for Engineering and the Environment
bgs	below ground surface
COC	contaminant of concern
CS	Chemical Spill
CSM	Conceptual Site Model
FS	Fuel Spill
ft	feet/foot
gpm	gallons per minute
HATF	Hunter Avenue Treatment Facility
MCL	Maximum Contaminant Level
MMR	Massachusetts Military Reservation
msl	mean sea level
RI	Remedial Investigation
SPEIM	System Performance and Ecological Impact Monitoring
TCE	trichloroethene
VI	vapor intrusion
VOC	volatile organic compound
µg/L	micrograms per liter

F1.0 CHEMICAL SPILL-21 VAPOR INTRUSION EVALUATION

F1.1 CS-21 CONCEPTUAL SITE MODEL

The Chemical Spill–21 (CS-21) groundwater plume is a dilute dissolved-phase groundwater plume located south of the Massachusetts Military Reservation (MMR) in Falmouth, Massachusetts (Figure 1-2 of main document), which is detached from its source area. The CS-21 plume (Figures F-1) is currently defined as the extent of groundwater containing the groundwater contaminant of concern (COC), trichloroethene (TCE), at concentrations greater than the Maximum Contaminant Level (MCL) of 5 micrograms per liter (µg/L).

The location of the source area for the CS-21 plume is unknown; however, the plume most likely originated in the southern portion of the MMR (Figure F-1). Evidence suggesting the presence of the CS-21 plume was first identified in 1997 when sub-MCL concentrations of TCE were detected in samples collected from residential wells in the area to the north of Route 151 (AFCEE 2000). The plume was further defined during the Southwest Operable Unit Remedial Investigation (RI) (AFCEE 1999). Although the specific source of the CS-21 plume has not been identified, potential source areas located hydraulically upgradient of the CS-21 plume were investigated and remediated (if needed) through the Installation Restoration Program in accordance with the established regulatory framework for the MMR sites (AFCEE 2008a, 2008b).

A plan view of the CS-21 plume, along with the location of the line of cross-section and monitoring locations used to support this vapor intrusion (VI) evaluation, are shown on Figure F-2. A cross-sectional view of the CS-21 TCE plume is provided as Figure F-3.

Based on the most recent depiction of the CS-21 plume boundary, the plume is approximately 7,900 feet (ft) long and has a maximum width of approximately 1,400 ft, extending from the Hunter Avenue Treatment Facility (HATF) area near the southern MMR boundary under Route 151, and terminating just west of Falmouth Woods Road at extraction wells 82EW0002 and 82EW0003 (Figure F-1). Characteristic of many of the MMR groundwater plumes, the CS-21 plume descended in the aquifer as it migrated from its source area due to recharge accretion,

which has resulted in the plume being located relatively deep in the aquifer and entirely overlain by a lens of clean groundwater. The CS-21 plume is up to approximately 180 ft thick in the aquifer and the upper boundary of the plume is between approximately 120 and 250 ft below ground surface (bgs) and between 50 and 130 ft below the water table (Figure F-3). The depiction of the plume shown in cross sectional view on Figure F-3 is based on data collected in 2011, whereas the plume boundary shown on Figures F-1 and F-2 is based on data collected in 2010.

The topography of the land above and in the vicinity of the CS-21 plume is generally flat with a ground elevation change of approximately 95 ft from west to east. Sub-regionally, the area is characterized by low rolling hills and flat areas of the Mashpee Pitted Plain, which is a broad, flat, gently southward-sloping glacial outwash plain (AFCEE 2000). Within the footprint of the plume, the maximum and minimum ground surface elevations are approximately 175 mean sea level (msl) and 80 ft msl, respectively.

The groundwater flow direction in the vicinity of the CS-21 plume is primarily to the southwest and flow within the aquifer is primarily horizontal. The depth to groundwater above and in the vicinity of the CS-21 plume ranges from approximately 40 to 130 ft bgs; the elevation of the water table within the CS-21 area ranges from approximately 35 ft msl in the southwest leading edge to 55 ft msl in the northeast portion of the plume. The aquifer saturated thickness in the CS-21 area ranges from approximately 200 to 310 ft.

The Air Force Center for Engineering and the Environment (AFCEE) issued a Record of Decision in 2000 which specified design and construction of a treatment system to address the CS-21 plume (AFCEE 2000). The CS-21 remedial system consists of four extraction wells (82EW0001 through 82EW0004), and is part of the Southwest Plumes remedial system, which was designed to collectively remediate the CS-4, CS-20, CS-21, and Fuel Spill-29 (FS-29) groundwater plumes (Figure F-1). The contaminated groundwater is captured by extraction wells in each plume and treated in a centrally located treatment plant, the HATF. The flow from the CS-21 extraction wells (and formerly from the FS-29 extraction wells when they were operational prior to September 2010) enters the HATF through a common influent line, and is treated through a series of granular activated carbon vessels. Likewise, the flow from the CS-4

and CS-20 extraction wells enters the HATF through a common influent line, and is treated through a second granular activated carbon treatment train. The treated water from the CS-21 and CS-4/CS-20 treatment trains exits the HATF in a combined effluent line and all treated water is returned to the aquifer through reinjection wells, an infiltration trench, and an infiltration gallery (AFCEE 2011).

The CS-21 remedial system began operation in September 2006 at a design flow rate of 1,400 gallons per minute (gpm) (AFCEE 2008c). In June 2010, the westernmost extraction well (82EW0004) was shut down when TCE concentrations in the leading edge of the plume decreased to below the MCL. The three remaining CS-21 extraction wells currently operate at a combined flow rate of 1,048 gpm (AFCEE 2012). The most recent transport model simulations predict that the remaining CS-21 extraction wells can be turned off by approximately 2024, and TCE concentrations in the upgradient portion of the CS-21 plume are expected to decline below the MCL through natural attenuation by approximately 2026.

F1.2 STEP 1: CLEAN WATER LENS

As established in Section 4.1.1 and depicted graphically in Figure 4-1 of the main document, the first step in evaluating the possibility of VI for a groundwater plume is determining whether a continuous 3-ft-thick clean water lens is present above the entire plume and is expected to remain for the foreseeable future as long as the plume exists. If so, it can be concluded that the VI pathway is incomplete and no further evaluation is required.

The clean water lens evaluation included a review of the analytical data for the CS-21 COC (TCE), as well as other plume-related volatile organic compounds (VOCs) included in the list of VI contaminants of potential concern in Table 4-1 of the main document. For this CS-21 VI evaluation, the absence of plume-related VOC detections in groundwater in the portion of the aquifer above the plume footprint will define the presence of clean water. The locations of all the monitoring points used for this VI evaluation are shown on Figure F-2. The most recent TCE data used to support this evaluation, and to illustrate the location of the plume in the aquifer, are shown on the southwest-northeast cross-sectional depiction of the CS-21 plume on Figure F-3,

and the analytical data are summarized in Table F-1. The well construction and sampling location information used in this evaluation is included in Table F-2.

As described in the conceptual site model (CSM) in Section F1.1, the most recent monitoring data indicate that the CS-21 plume is located deep in the aquifer. In addition, historic characterization data collected during the RI (AFCEE 1999) and the pre-remedial system design investigation (AFCEE 2003), as well as recent data collected under the System Performance and Ecological Impact Monitoring (SPEIM) program, confirm that the CS-21 plume is overlain by a substantial thickness of clean water well in excess of 3 ft. The data that support this aspect of the CSM are as follows and are presented on Figure F-2 and Figure F-3, and in Table F-1:

- Groundwater vertical profile data collected during a 2009 data gap investigation at direct push drilling locations 82DP0001 through 82DP0005 and 82DP0008 indicate the presence of a clean water lens in excess of 10 ft above the CS-21 plume.
- Monitoring data collected at the following monitoring wells screened shallower in the aquifer than the CS-21 plume, in order of most recent to oldest, were used to confirm the presence of a clean water lens: 82MW0016B (2011), 82MW0019B (2009), 82MW0015B (2009), 82MW0009B (2009), 82MW0003B (2009), 82MW0014B (2002), and 69MW1534B (2002). It is noted that monitoring wells 82MW0003B, 82MW0014B and 82MW0016B are outside the current plume footprint; however these wells were within the plume footprint in the past and therefore data from these locations are useful to support the concept of a clean water lens above the CS-21 plume as described in the CSM.
- Groundwater vertical profile data collected above the CS-21 plume during rotosonic drilling at 82MW0003A (2000), 82MW0006A (2001), 82MW0010A (2002), 82MW0012A (2001), 82MW0014A (2001), 82MW0016A (2001), and 82MW0017A (2001) indicate the presence of at least a 20 ft thickness of clean water above the plume at that time. It is noted that 82MW0014A and 82MW0016A are now located outside of the plume footprint to the west and north, respectively; however, those borings were within the CS-21 plume boundary when they were installed in 2001.
- Groundwater vertical profile data collected above the CS-21 plume during rotosonic drilling at 69MW1510A, 69MW1514A, 69MW1529, and 69MW1539 in 1998 indicates the presence of at least a 30 ft thickness of clean water above the plume at that time. It is noted that 69MW1539 is now located outside of the plume footprint to the west; however, when installed in 1998, the leading edge of the CS-21 plume was present in this area and the data support the overall concept of a clean water lens above the plume.

In summary, characterization and monitoring data from multiple locations throughout the area of the CS-21 plume confirm the presence of a clean water lens overlying the entire plume well in excess of the 3-ft thickness criterion used for this VI screening evaluation. It is acknowledged, however, that some of these characterization data are not recent (i.e., dating back to 1998 in some cases), but when combined with more recent data collected in 2011 and the overall understanding of the hydrogeologic aspect of the CSM, they still provide sound lines of evidence that the CS-21 plume is located deep in the aquifer and is overlain by a substantial thickness of clean water. Furthermore, given the substantial thickness of clean water above the whole plume, and the ongoing remedial actions, a change in the clean water lens presence is not anticipated in the future.

F2.0 CONCLUSIONS AND RECOMMENDATIONS

F2.1 CONCLUSIONS

A review of groundwater characterization and monitoring data collected at CS-21 indicates that a continuous clean water lens at least 3 ft thick is present above the entire body of the CS-21 plume and is expected to be present in the future as long as the plume exists. As evidenced by data indicating the presence of a substantial clean water lens overlying the entire extent of the CS-21 plume, and the ongoing remedial actions, the VI exposure pathway at CS-21 is incomplete, and further evaluation of VI associated with the CS-21 plume is not necessary.

F2.2 RECOMMENDATIONS

No further monitoring or data collection is needed specific to VI. However, as part of the ongoing remedial actions at CS-21, AFCEE will continue to monitor the nature and extent of the CS-21 plume under the SPEIM program and will re-evaluate the VI exposure pathway if conditions change such that VI could become a concern.

F3.0 REFERENCES

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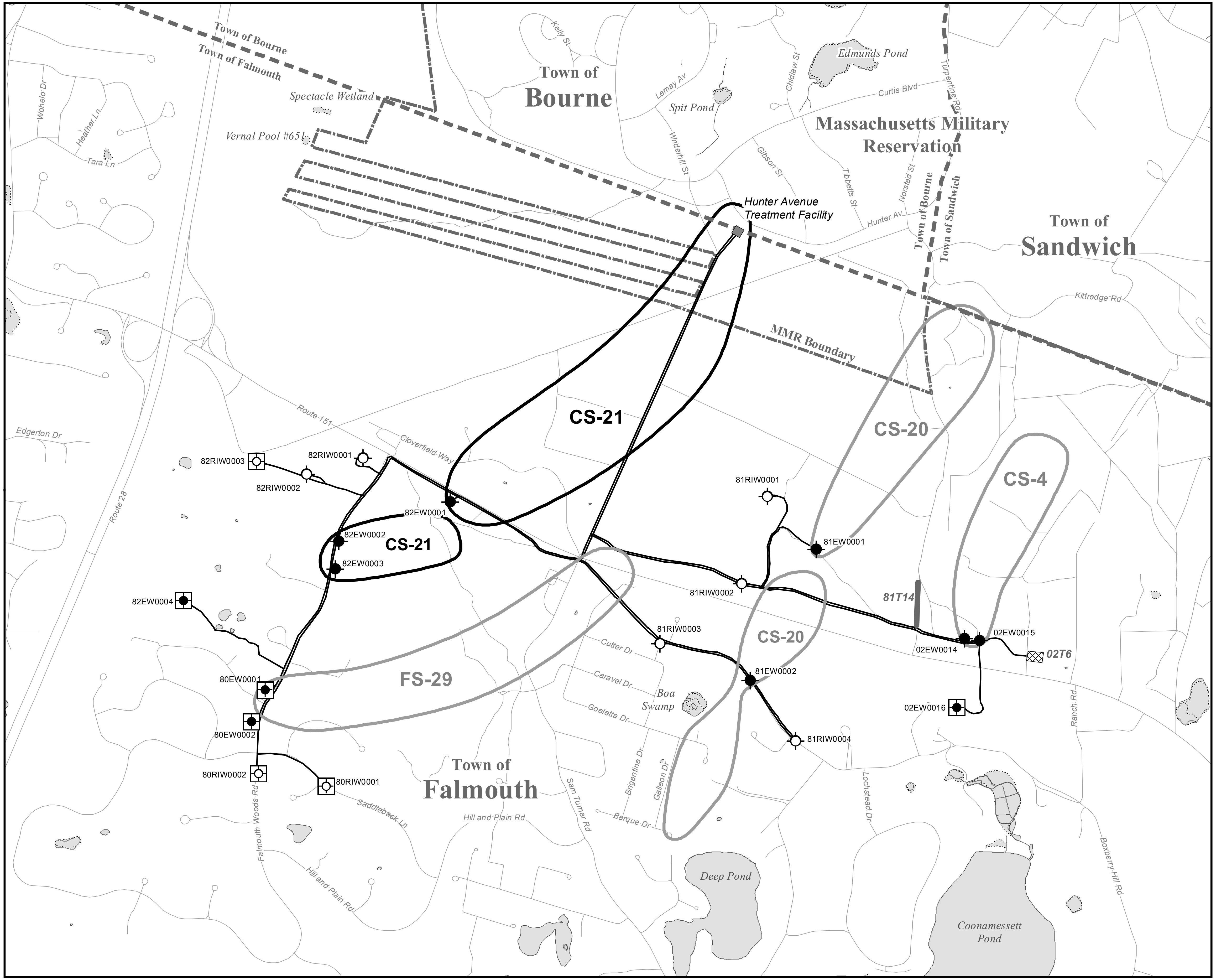

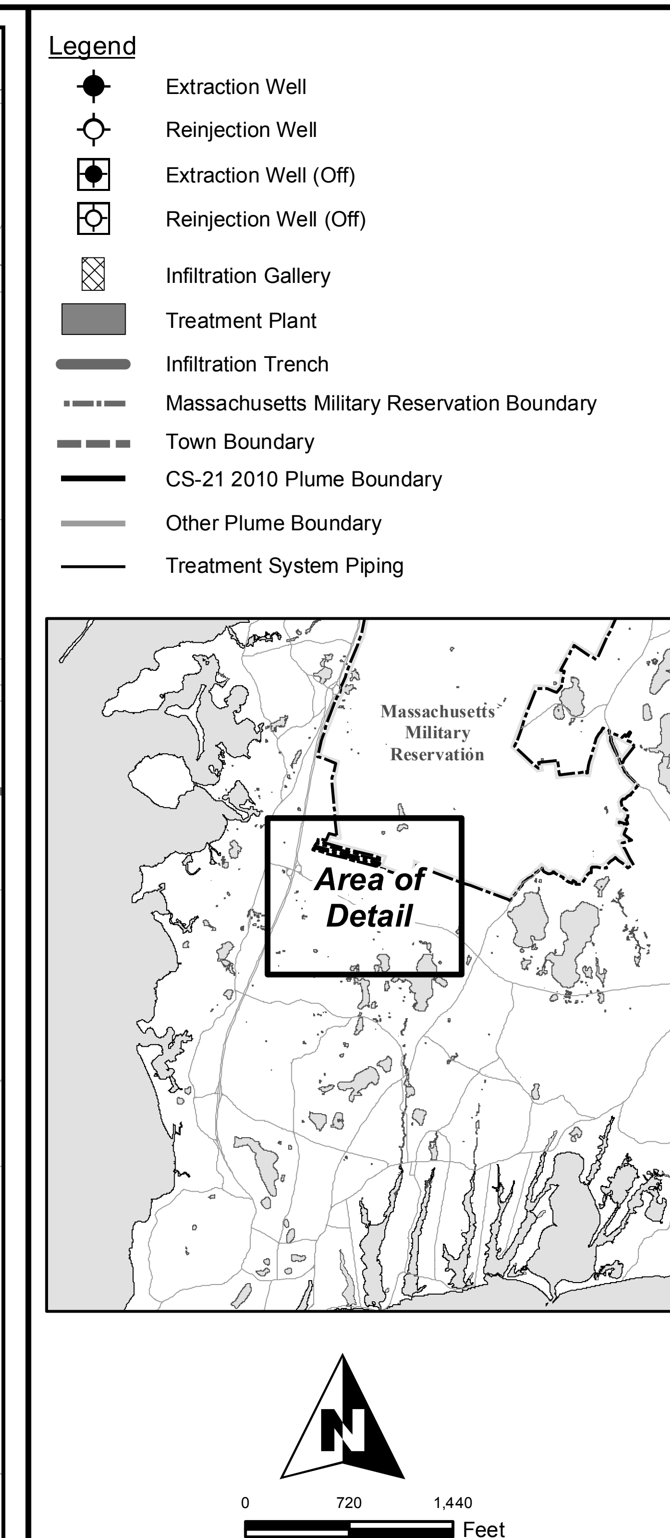

Data Source: AFCEE, December 2011, MMR-AFCEE Data Warehouse
MMR Boundary from Massachusetts Air National Guard 2011

FIGURE F-1

CS-21 GROUNDWATER PLUME AND SOUTHWEST PLUMES REMEDIAL SYSTEM LAYOUT

AFCEE - Massachusetts Military Reservation

Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

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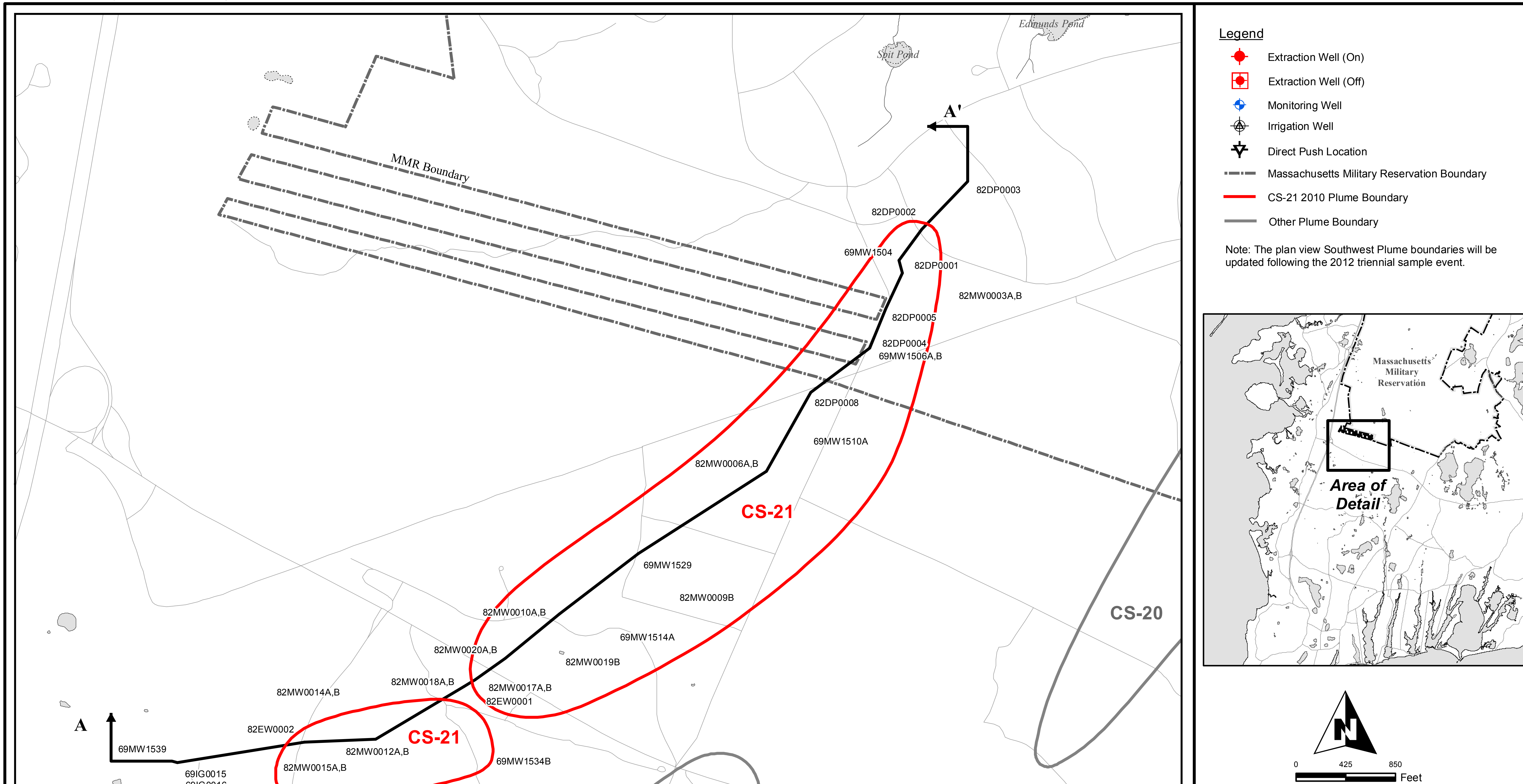

Data Source: AFCEE, December 2011, MMR-AFCEE Data Warehouse
MMR boundary from MA ARNG 2011

FIGURE F- 2

CS-21 GROUNDWATER PLUME AND LOCATION OF CROSS-SECTION LINE

AFCEE - Massachusetts Military Reservation

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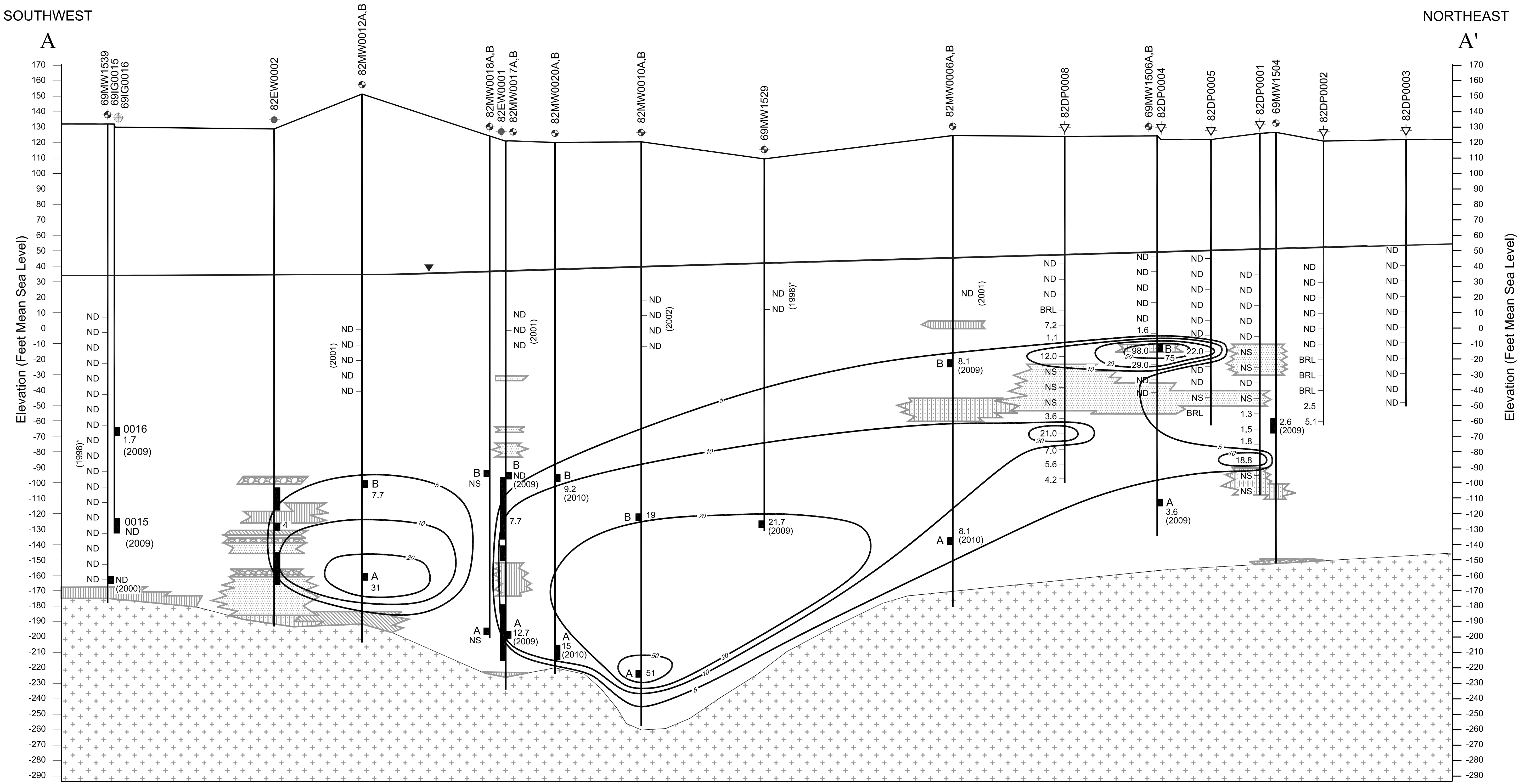

Legend

Monitoring Well	ND Nondetect	A Well Screen ID	Clay	Fine Sand	
Irrigation Well	BRL Below Reporting Limit	— 5 — TCE Isoconcentration Contour (MCL = 5 µg/L) (Dashed Where Inferred)	Silt	Gravelly Sand	
Extraction Well	NS Not Sampled				
Direct Push Location	2.7 TCE Data (µg/L) Collected in 2011, Unless Otherwise Noted	1.2 TCE Vertical Profile Data (µg/L) Collected April - October, 2009 Unless Otherwise Noted	Silty Sand	Bedrock	
Water Table (04/2009)					

Data Source: AFCEE, December 2011, MMR-AFCEE Data Warehouse.

Notes:
1) This cross-section presents the most recent (2011 unless otherwise noted) data for CS-21, but does not correspond to the 2010 plume boundary presented on Figure F-2. The plan view Southwest Plume boundaries will be updated following the 2012 triennial sampling event.
2) *Vertical profile data collected in 1998 presented in Appendix G of the Final Southwest Operable Unit (SWOU) Remedial Investigation (AFCEE 1999).
3) Vertical profile data collected prior to 2011 from the shallowest intervals are shown to support the VI clean water lens evaluation.

V: 65
H: 693
0
Feet

FIGURE F-3

CS-21 CROSS-SECTION A-A'

AFCEE - Massachusetts Military Reservation

Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

CH2MHILL.

Table F-1
CS-21 Groundwater Data Used in Support of VI Evaluation
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Location	Date Sampled	Mid-Sample Elevation (ft msl)	Sampling Method[1]	Result[2]
69MW1510A	3/6/1998	41.47	VP	No detections of plume-related VI COPCs
69MW1510A	3/6/1998	31.47	VP	No detections of plume-related VI COPCs
69MW1510A	3/6/1998	21.47	VP	No detections of plume-related VI COPCs
69MW1514A	3/16/1998	31.79	VP	No detections of plume-related VI COPCs
69MW1514A	3/16/1998	20.79	VP	No detections of plume-related VI COPCs
69MW1514A	3/16/1998	10.79	VP	No detections of plume-related VI COPCs
69MW1514A	3/16/1998	0.79	VP	No detections of plume-related VI COPCs
69MW1529	4/16/1998	21.98	VP	No detections of plume-related VI COPCs
69MW1529	4/16/1998	11.98	VP	No detections of plume-related VI COPCs
69MW1534B	6/17/2002	-62.15	MW	No detections of plume-related VI COPCs
69MW1539	5/19/1998	7.03	VP	No detections of plume-related VI COPCs
69MW1539	5/19/1998	-2.97	VP	No detections of plume-related VI COPCs
69MW1539	5/19/1998	-12.97	VP	No detections of plume-related VI COPCs
69MW1539	5/19/1998	-22.97	VP	No detections of plume-related VI COPCs
69MW1539	5/19/1998	-32.97	VP	No detections of plume-related VI COPCs
69MW1539	5/19/1998	-42.97	VP	No detections of plume-related VI COPCs
69MW1539	5/19/1998	-52.97	VP	No detections of plume-related VI COPCs
69MW1539	5/19/1998	-62.97	VP	No detections of plume-related VI COPCs
69MW1539	5/20/1998	-72.97	VP	No detections of plume-related VI COPCs
69MW1539	5/20/1998	-82.97	VP	No detections of plume-related VI COPCs
69MW1539	5/20/1998	-92.97	VP	No detections of plume-related VI COPCs
69MW1539	5/20/1998	-102.97	VP	No detections of plume-related VI COPCs
69MW1539	5/20/1998	-112.97	VP	No detections of plume-related VI COPCs
69MW1539	5/20/1998	-122.97	VP	No detections of plume-related VI COPCs
69MW1539	5/20/1998	-132.97	VP	No detections of plume-related VI COPCs
69MW1539	5/21/1998	-142.97	VP	No detections of plume-related VI COPCs
69MW1539	5/21/1998	-152.97	VP	No detections of plume-related VI COPCs
69MW1539	5/21/1998	-162.97	VP	No detections of plume-related VI COPCs
82DP0001	4/2/2009	34.50	VP	No detections of plume-related VI COPCs
82DP0001	4/2/2009	24.50	VP	No detections of plume-related VI COPCs
82DP0001	4/2/2009	14.50	VP	No detections of plume-related VI COPCs
82DP0001	4/2/2009	4.50	VP	No detections of plume-related VI COPCs
82DP0001	4/2/2009	-5.50	VP	No detections of plume-related VI COPCs
82DP0002	4/7/2009	39.50	VP	No detections of plume-related VI COPCs
82DP0002	4/7/2009	29.50	VP	No detections of plume-related VI COPCs
82DP0002	4/7/2009	19.50	VP	No detections of plume-related VI COPCs
82DP0002	4/7/2009	9.50	VP	No detections of plume-related VI COPCs
82DP0002	4/7/2009	-0.50	VP	No detections of plume-related VI COPCs
82DP0002	4/7/2009	-10.50	VP	No detections of plume-related VI COPCs
82DP0003	6/17/2009	49.50	VP	No detections of plume-related VI COPCs
82DP0003	6/17/2009	39.50	VP	No detections of plume-related VI COPCs
82DP0003	6/17/2009	29.50	VP	No detections of plume-related VI COPCs
82DP0003	6/17/2009	19.50	VP	No detections of plume-related VI COPCs
82DP0003	6/17/2009	9.50	VP	No detections of plume-related VI COPCs
82DP0003	6/18/2009	-0.50	VP	No detections of plume-related VI COPCs
82DP0003	6/18/2009	-10.50	VP	No detections of plume-related VI COPCs

Table F-1
CS-21 Groundwater Data Used in Support of VI Evaluation
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Location	Date Sampled	Mid-Sample Elevation (ft msl)	Sampling Method[1]	Result[2]
82DP0003	6/18/2009	-20.50	VP	No detections of plume-related VI COPCs
82DP0003	6/18/2009	-30.50	VP	No detections of plume-related VI COPCs
82DP0003	6/19/2009	-40.50	VP	No detections of plume-related VI COPCs
82DP0003	6/19/2009	-49.88	VP	No detections of plume-related VI COPCs
82DP0004	6/23/2009	44.50	VP	No detections of plume-related VI COPCs
82DP0005	10/1/2009	44.50	VP	No detections of plume-related VI COPCs
82DP0008	8/17/2009	41.50	VP	No detections of plume-related VI COPCs
82MW0003A	11/15/2000	21.64	VP	No detections of plume-related VI COPCs
82MW0003A	11/15/2000	11.64	VP	No detections of plume-related VI COPCs
82MW0003A	11/15/2000	1.64	VP	No detections of plume-related VI COPCs
82MW0003B	4/10/2009	-48.16	MW	No detections of plume-related VI COPCs
82MW0006A	6/4/2001	22.09	VP	No detections of plume-related VI COPCs
82MW0009B	5/5/2009	-60.43	MW	No detections of plume-related VI COPCs
82MW0010A	4/3/2002	18.03	VP	No detections of plume-related VI COPCs
82MW0010A	4/3/2002	8.03	VP	No detections of plume-related VI COPCs
82MW0010A	4/3/2002	-1.97	VP	No detections of plume-related VI COPCs
82MW0010A	4/3/2002	-11.97	VP	No detections of plume-related VI COPCs
82MW0012A	1/24/2001	-1.06	VP	No detections of plume-related VI COPCs
82MW0012A	1/25/2001	-11.06	VP	No detections of plume-related VI COPCs
82MW0012A	1/25/2001	-21.06	VP	No detections of plume-related VI COPCs
82MW0012A	1/25/2001	-31.06	VP	No detections of plume-related VI COPCs
82MW0012A	1/25/2001	-41.06	VP	No detections of plume-related VI COPCs
82MW0014A	1/11/2001	-3.38	VP	No detections of plume-related VI COPCs
82MW0014A	1/11/2001	-13.38	VP	No detections of plume-related VI COPCs
82MW0014A	1/15/2001	-23.38	VP	No detections of plume-related VI COPCs
82MW0014A	1/15/2001	-33.38	VP	No detections of plume-related VI COPCs
82MW0014A	1/15/2001	-43.38	VP	No detections of plume-related VI COPCs
82MW0014A	1/15/2001	-53.38	VP	No detections of plume-related VI COPCs
82MW0014A	1/16/2001	-63.38	VP	No detections of plume-related VI COPCs
82MW0014A	1/16/2001	-73.38	VP	No detections of plume-related VI COPCs
82MW0014A	1/16/2001	-87.38	VP	No detections of plume-related VI COPCs
82MW0014A	1/16/2001	-94.88	VP	No detections of plume-related VI COPCs
82MW0014A	1/17/2001	-103.38	VP	No detections of plume-related VI COPCs
82MW0014A	1/17/2001	-113.38	VP	No detections of plume-related VI COPCs
82MW0014A	1/17/2001	-123.38	VP	No detections of plume-related VI COPCs
82MW0014A	1/17/2001	-133.38	VP	No detections of plume-related VI COPCs
82MW0014A	1/18/2001	-143.38	VP	No detections of plume-related VI COPCs
82MW0014A	1/18/2001	-153.38	VP	No detections of plume-related VI COPCs
82MW0014B	7/9/2002	-74.83	MW	No detections of plume-related VI COPCs
82MW0015B	5/11/2009	-89.66	MW	No detections of plume-related VI COPCs
82MW0016A	10/31/2001	-31.52	VP	No detections of plume-related VI COPCs
82MW0016A	10/31/2001	-41.52	VP	No detections of plume-related VI COPCs
82MW0016A	11/1/2001	-51.52	VP	No detections of plume-related VI COPCs
82MW0016A	11/1/2001	-61.52	VP	No detections of plume-related VI COPCs
82MW0016A	11/1/2001	-71.52	VP	No detections of plume-related VI COPCs
82MW0016A	11/1/2001	-81.52	VP	No detections of plume-related VI COPCs
82MW0016A	11/1/2001	-91.52	VP	No detections of plume-related VI COPCs
82MW0016A	11/1/2001	-101.52	VP	No detections of plume-related VI COPCs
82MW0016B	4/8/2011	-80.98	MW	No detections of plume-related VI COPCs

Table F-1
CS-21 Groundwater Data Used in Support of VI Evaluation
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Location	Date Sampled	Mid-Sample Elevation (ft msl)	Sampling Method[1]	Result[2]
82MW0017A	8/6/2002	8.44	VP	No detections of plume-related VI COPCs
82MW0017A	8/7/2002	-1.56	VP	No detections of plume-related VI COPCs
82MW0017A	8/7/2002	-11.56	VP	No detections of plume-related VI COPCs
82MW0019B	5/12/2009	-112.50	MW	No detections of plume-related VI COPCs

Data Source: AFCEE, December 2011, MMR-AFCEE Data Warehouse

Notes:

1. Sample collection methodology:
   VP = vertical profile groundwater sampling (direct push, rotosonic, or screened hollow-stem auger drilling methods)
   MW = fixed monitoring well
2. See Table 4-1 of the main document for a complete list of VI COPCs.

The data summarized in this table specifically support the CS-21 clean water lens VI evaluation and typically include the most recent sampling results for each location for the plume-related VI COPCs only. If additional historic sampling data exist, they are available for review in the AFCEE-MMR Data Warehouse.

Vertical profile data presented only includes the relevant sample intervals used to support this CS-21 VI evaluation; if analytical data from deeper sample intervals exist, they are available in the AFCEE MMR Data Warehouse.

Key:

COPC = contaminant of potential concern
CS-21 = Chemical Spill-21
ft msl = feet mean sea level
VI = vapor intrusion

Table F-2
CS-21 Well Construction and Sample Location Information
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Location	Northing (ft)	Easting (ft)	Surface Elevation (ft msl)	Measuring Point Elevation (ft msl)	Total Well Depth (ft bgs)	Top Screen Depth (ft bgs)	Bottom Screen Depth (ft bgs)	Top Screen Elevation (ft msl)	Bottom Screen Elevation (ft msl)	Screen Length (ft)
69MW1510A	235808	851277	124	126.37	176	171.10	176.10	-47.13	-52.13	5
69MW1514A	234180	849720	104	104.08	288	283.40	287.80	-179.11	-183.51	5
69MW1529	234983	849678	109	110.97	239	234.00	239.00	-124.52	-129.52	5
69MW1534B	233207	848367	121	123.01	185	180.20	185.20	-59.65	-64.65	5
69MW1539	233208	845690	132	131.71	298	292.50	297.50	-160.47	-165.47	5
82DP0001	237381	851936	126	NA	NA	NA	NA	NA	NA	NA
82DP0002	237754	852101	121	NA	NA	NA	NA	NA	NA	NA
82DP0003	238165	852496	122	NA	NA	NA	NA	NA	NA	NA
82DP0004	236756	851662	122	NA	NA	NA	NA	NA	NA	NA
82DP0005	237075	851793	122	NA	NA	NA	NA	NA	NA	NA
82DP0008	236360	851154	124	NA	NA	NA	NA	NA	NA	NA
82MW0003A	237268	852363	124	123.69	215	209.59	214.61	-85.45	-90.47	5
82MW0003B	237268	852362	124	123.68	175	169.79	174.81	-45.65	-50.67	5
82MW0006A	235686	850774	125	124.28	265	259.88	265.00	-135.29	-140.41	5
82MW0009B	234527	849967	101	101.00	165	159.32	164.32	-57.93	-62.93	5
82MW0010A	234465	849003	121	120.08	347	341.97	346.77	-221.44	-226.24	5
82MW0012A	233393	847433	151	153.55	315	310.00	315.00	-158.56	-163.56	5
82MW0014A	233713	847169	159	161.29	321	315.80	320.70	-156.68	-161.58	5
82MW0014B	233713	847169	159	161.27	237	231.40	236.50	-72.28	-77.38	5
82MW0015B	233064	846769	123	122.44	216	210.00	215.00	-87.16	-92.16	5
82MW0016A	232869	845856	131	130.28	255	250.25	255.00	-119.27	-124.02	5
82MW0016B	232869	845856	131	130.28	215	209.57	214.34	-78.59	-83.36	5
82MW0017A	233903	848284	121	120.73	322	317.20	322.00	-196.26	-201.06	5
82MW0019B	234001	848990	114	113.51	229	224.01	228.83	-110.09	-114.91	5

Data Source: AFCEE, December 2011, MMR-AFCEE Data Warehouse

Key:
bgs = below ground surface
CS-21 = Chemical Spill-21
ft = feet
msl = mean sea level
NA = data not available; locations are direct push vertical profile locations and have no screen information.

APPENDIX G

CS-23 Vapor Intrusion Evaluation

TABLE OF CONTENTS

Figures

Tables

ACRONYMS AND ABBREVIATIONS

AFCEE	Air Force Center for Engineering and the Environment
bgs	below ground surface
BBM	Buzzards Bay Moraine
CCl_4	carbon tetrachloride
COC	contaminant of concern
CS	Chemical Spill
CSM	Conceptual Site Model
EPA	U.S. Environmental Protection Agency
FS	Fuel Spill
ft	feet/foot
gpm	gallons per minute
HATF	Hunter Avenue Treatment Facility
LF	Landfill
MCL	Maximum Contaminant Level
MMR	Massachusetts Military Reservation
msl	mean sea level
PEST	Parameter Estimation
SPEIM	System Performance and Ecological Impact Monitoring
TCE	trichloroethene
VI	vapor intrusion
VOC	volatile organic compound
µg/L	micrograms per liter

G1.0 CHEMICAL SPILL-23 VAPOR INTRUSION EVALUATION

G1.1 CS-23 CONCEPTUAL SITE MODEL

The Chemical Spill–23 (CS-23) groundwater plume is a dilute dissolved-phase groundwater plume located near the southwest corner of the Massachusetts Military Reservation (MMR). It extends off-base a short distance into the Town of Falmouth (Figure 1-2 of main document) and is detached from its source area. The CS-23 plume (Figure G-1) is currently defined as the extent of groundwater containing the primary CS-23 groundwater contaminant of concern (COC), trichloroethene (TCE), at concentrations greater than the Maximum Contaminant Level (MCL) of 5 micrograms per liter (μg/L). Carbon tetrachloride (CCl_4) is also a COC at CS-23; however, CCl_4 has not been detected in the CS-23 monitoring network at concentrations above the MCL of 5 μg/L since February 2005.

The location of the source area for the CS-23 plume is unknown; however, the plume most likely originated in the southern portion of the MMR (Figure G-1). The CS-23 plume was first detected in 2000 during the CS-4, CS-20, CS-21, and Fuel Spill-29 (FS-29) pre-design investigation (AFCEE 2003), and was defined as a groundwater plume in 2002. Although the specific source of the CS-23 plume has not been identified, potential source areas located hydraulically upgradient of the CS-23 plume were investigated and remediated (if needed) through the Installation Restoration Program in accordance with the established regulatory framework for the MMR sites (AFCEE 2008).

A plan view of the CS-23 plume, along with the location of the line of cross-section and monitoring locations used to support this vapor intrusion (VI) evaluation, are shown on Figure G-2. A cross-sectional view of the CS-23 TCE plume is provided as Figure G-3.

Based on the most recent depiction of the CS-23 plume boundary, the plume extends from the southwestern edge of Osborn Pond (within the MMR) in a west-southwesterly direction approximately 5,600 feet (ft) to just beyond extraction well 27EW0008 near the MMR boundary and has a maximum width of approximately 950 ft (Figure G-1). Characteristic of many of the MMR groundwater plumes, the CS-23 plume descended in the aquifer as it migrated from its

source area due to recharge accretion, which has resulted in the plume being located relatively deep in the aquifer and entirely overlain by a lens of clean groundwater. The CS-23 plume is up to 100 ft thick in the aquifer and the upper boundary of the plume is between approximately 110 and 205 ft below ground surface (bgs) and between 90 and 135 ft below the water table (Figure G-3).

The topography of the land in the northeastern portion of the CS-23 plume can be characterized as broad, flat, and gently sloping glacial outwash plain. The southwestern portion of the plume travels into the Buzzards Bay Moraine (BBM), which is a hummocky north-south trending ridge of glacial deposits. Within the footprint of the plume, the maximum and minimum ground surface elevations are approximately 205 ft mean sea level (msl), and 50 ft msl, respectively (AFCEE 2012b).

The groundwater flow direction in the vicinity of the CS-23 plume is generally from east-northeast to west-southwest and flow within the aquifer is primarily horizontal. The depth to groundwater above and in the vicinity of the CS-23 plume ranges from less than a few feet near the kettle pond Osborn Pond to approximately 170 ft bgs below the top of the BBM (i.e., the highest ground surface elevation) near the CS-23 extraction wells 27EW0007 and 27EW0008; the elevation of the water table within the CS-23 area is approximately 60 ft msl near Osborn Pond and approximately 40 ft msl near the CS-23 extraction wells. The aquifer saturated thickness is approximately 200 to 225 ft.

The Air Force Center for Engineering and the Environment (AFCEE) issued a Record of Decision in 2007 which specified treatment of the CS-23 plume with an on-base groundwater remedial system (AFCEE 2007). The ongoing remedial actions at CS-23 are currently managed under the System Performance and Ecological Impact Monitoring (SPEIM) program. The close proximity of the CS-23 and Landfill-1 (LF-1) plumes and remedial systems warrant that the LF-1 and CS-23 SPEIM programs be combined; therefore, data collection, data assessment, groundwater modeling, and reporting are performed jointly under a combined LF-1/CS-23 SPEIM program. The LF-1/CS-23 remedial system is comprised of six LF-1 extraction wells, one LF-1 reinjection well, two CS-23 extraction wells (27EW0007 and 27EW0008), two LF-1/CS-23 infiltration trenches (the East and West trenches), and two water treatment plants

(AFCEE 2011). The extraction wells are aligned in a roughly north-south orientation parallel with the MMR western base boundary (Figure G-1). The expanded LF-1/CS-23 remedial system became operational on 05 December 2006 with 595 gallons per minute (gpm) being treated at the LF-1 treatment plant, and 1,350 gpm being treated through the LF-1/CS-23 treatment train at the Hunter Avenue Treatment Facility (HATF). The original wellfield design extraction rate for 27EW0007 and for 27EW0008 was 350 gpm at each extraction well. At a Technical Update meeting on 16 March 2011, AFCEE presented a Parameter Estimation (PEST) modeling approach to optimize the LF-1/CS-23 treatment systems which was verbally approved by the regulators at the meeting (based on AFCEE's understanding and meeting notes). AFCEE implemented the revised flow rates on 16 March 2011, which included a reduction in flow rates from 595 gpm to 525 gpm at LF-1 and from 1,350 gpm to 1,071 gpm at HATF LF-1/CS-23. The flow rates at the two CS-23 extraction wells were changed from 350 gpm to 151 gpm at 27EW0007 and from 350 gpm to 184 gpm at 27EW0008. During an optimization discussion meeting with the U.S. Environmental Protection Agency (EPA) and Massachusetts Department of Environmental Protection on 18 June 2012, EPA requested AFCEE return the LF-1/CS-23 flow rates to the pre-PEST optimization scenario to allow time for further review of the PEST modeling approach. AFCEE has returned the LF-1/CS-23 flow rates to pre-PEST conditions. The most recent transport modeling simulations predict that the CS-23 extraction wells can be turned off by approximately 2025, and TCE concentrations throughout the CS-23 plume are expected to decline below the MCL through natural attenuation by approximately 2053 (AFCEE 2012a).

G1.2 STEP 1: CLEAN WATER LENS

As established in Section 4.1.1 and depicted graphically in Figure 4-1 of the main document, the first step in evaluating the possibility of VI for a groundwater plume is determining whether a continuous 3-ft-thick clean water lens is present above the entire plume and is expected to remain for the foreseeable future as long as the plume exists. If the evaluation indicates that a clean water lens is present using the criteria presented in Section 4.1.1 of the main document, it can be concluded that the VI pathway is incomplete and no further evaluation is required.

The clean water lens evaluation included a review of the analytical data for the CS-23 COCs (TCE and CCl_4), as well as other plume-related volatile organic compounds (VOCs) included in the list of VI contaminants of potential concern in Table 4-1 of the main document. For this CS-23 evaluation, the absence of plume-related VOC detections in groundwater in the portion of the aquifer above the plume footprint will define the presence of clean water. The locations of all the monitoring points used for this VI evaluation are shown on Figure G-2. The most recent TCE data used to support this evaluation, and to illustrate the location of the plume in the aquifer, are shown on the southwest-northeast cross-sectional depiction of the CS-23 plume on Figure G-3, and the analytical data are summarized in Table G-1. The well construction and sampling location information used in this evaluation are included in Table G-2.

As described in the conceptual site model (CSM) in Section G1.1, the most recent monitoring data indicate that the CS-23 plume is located deep in the aquifer. In addition, historic characterization data collected during various investigations (AFCEE 2003, 2005, 2006, 2009) as well as recent data collected under the SPEIM program, confirm that the CS-23 plume is overlain by a substantial thickness of clean water well in excess of 3 ft. The data that support this aspect of the CSM are as follows and are presented on Figure G-2, Figure G-3, and in Table G-1:

- Groundwater vertical profile data collected during the installation of extraction well 27EW0008 in 2006 indicate the presence of at least a 10 ft thickness of clean water above the CS-23 plume.
- Groundwater vertical profile data collected at sample elevations above the CS-23 plume at 69MW1716A and 69MW1717A in 2005 confirm the presence of at least a 50 ft thickness of clean water above the CS-23 plume. 69MW1716A is now located outside of the CS-23 plume boundary but was within the plume boundary when it was installed, and the data support the overall concept of a clean water lens above the plume.
- Groundwater vertical profile data collected at sample elevations above the CS-23 plume at 69MW1708A, 69MW1709A, 69MW1710A, 69MW1714A, and 69MW1715A in 2003/2004 indicate the presence of at least a 40 ft thickness of clean water above the plume at that time. 69MW1710A is now located outside of the CS-23 plume boundary but was close to the plume boundary when it was installed, and the data support the overall concept of a clean water lens above the plume.
- Groundwater vertical profile data collected at sample elevations above the CS-23 plume at 69MW1701A, 69MW1704A, and 69MW1706A in 2001/2002 confirm the presence of at least a 20 ft thickness of clean water above the CS-23 plume at that time. 69MW1701A and 69MW1706A are now located outside of the CS-23 plume boundary but were within the

plume boundary when they were installed, and the data support the overall concept of a clean water lens above the plume.

- Groundwater vertical profile data collected above the CS-23 plume at 69MW1502 in 1998 indicate the presence of at least a 40 ft thickness of clean water above the plume at that time.
- Monitoring data collected at the following wells screened above the CS-23 plume in 2011 were used to confirm the current presence of a clean water lens: 27MW0023A, 69MW1701A, 69MW1704A, 69MW1706B, 69MW1707B, and 69MW1708B.

In summary, characterization and monitoring data from multiple locations throughout the area of the CS-23 plume confirm the presence of a clean water lens overlying the entire plume well in excess of the 3-ft thickness criterion used for this VI screening evaluation. It is acknowledged, however, that some of these characterization data are not recent (i.e., dating back to 1998 in some cases). But when combined with more recent data collected through 2011 and the overall understanding of the hydrogeologic aspect of the CSM, they still provide sound lines of evidence that the CS-23 plume is located deep in the aquifer and is overlain by a substantial thickness of clean water. Furthermore, given the substantial thickness of clean water above the entire plume, the low concentrations and limited extent of the plume, and ongoing remedial actions, a change in the clean water lens presence is not anticipated in the future.

G2.0 CONCLUSIONS AND RECOMMENDATIONS

G2.1 CONCLUSIONS

A review of groundwater characterization and monitoring data collected at CS-23 indicates that a continuous clean water lens at least 3 ft thick is present above the entire body of the CS-23 plume and is expected to be present in the future as long as the plume exists. As evidenced by data indicating the presence of a substantial clean water lens overlying the entire extent of the CS-23 plume, and the ongoing remedial actions, the VI exposure pathway at CS-23 is incomplete, and further evaluation of VI associated with the CS-23 plume is not necessary.

G2.2 RECOMMENDATIONS

No further monitoring or data collection is needed specific to VI. However, as part of the ongoing remedial actions at CS-23, AFCEE will continue to monitor the nature and extent of the CS-23 plume under the SPEIM program and will re-evaluate the VI exposure pathway if conditions change such that VI could become a concern.

G3.0 REFERENCES

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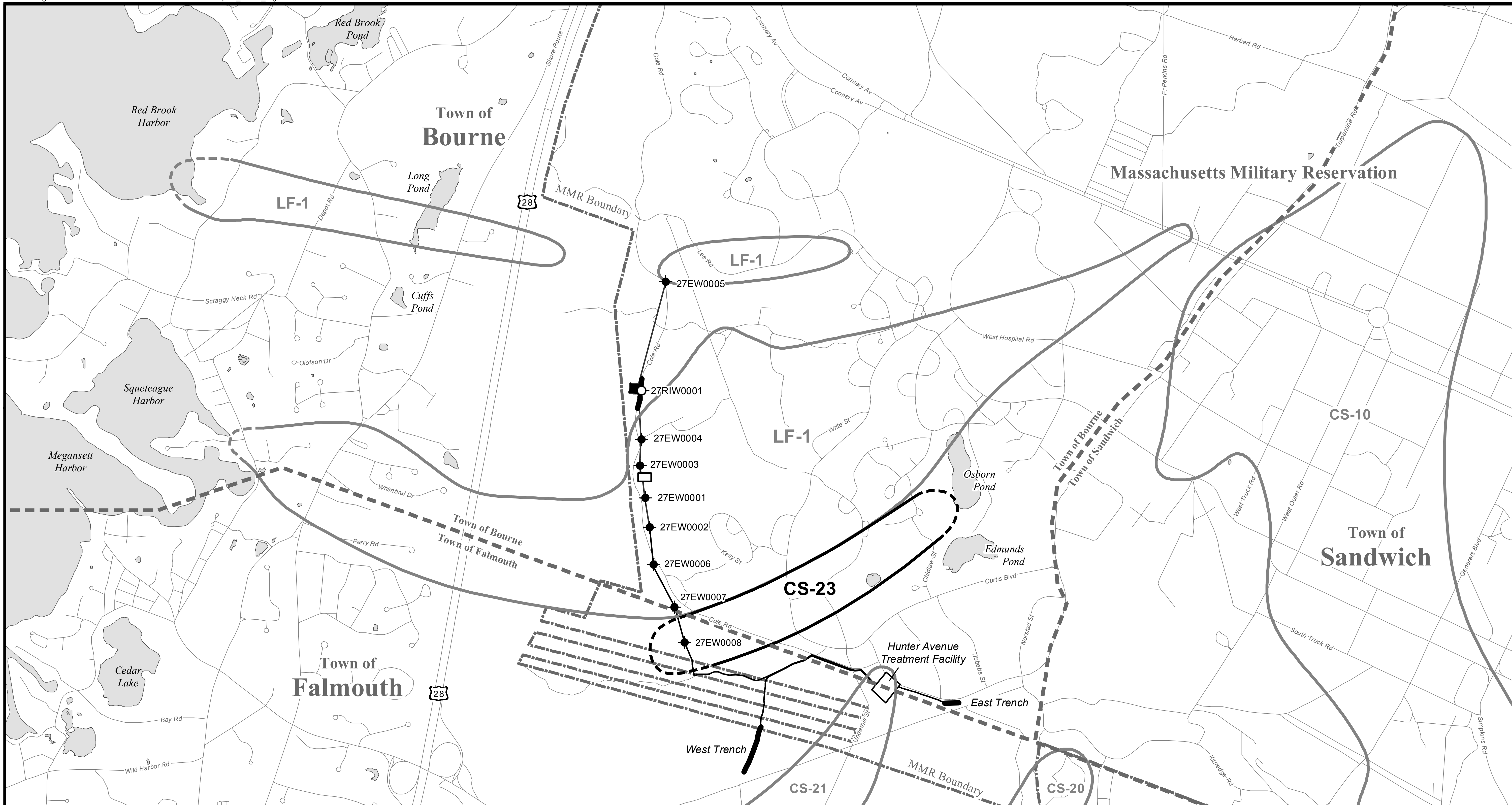


Data Source: AFCEE, January 2012, AFCEE-MMR Data Warehouse
MMR Boundary from Massachusetts Air National Guard 2011

Legend

- Extraction Well
- Reinjection Well
- Treatment Plant
- Town Boundary
- LF-1/CS-23 Treatment System Pipeline
- Infiltration Trench/Gallery
- Massachusetts Military Reservation Boundary
- CS-23 Plume Boundary (Dashed Where Inferred)
- Other Plume Boundary (Dashed Where Inferred)

N

0 850 1,700
Feet

FIGURE G-1

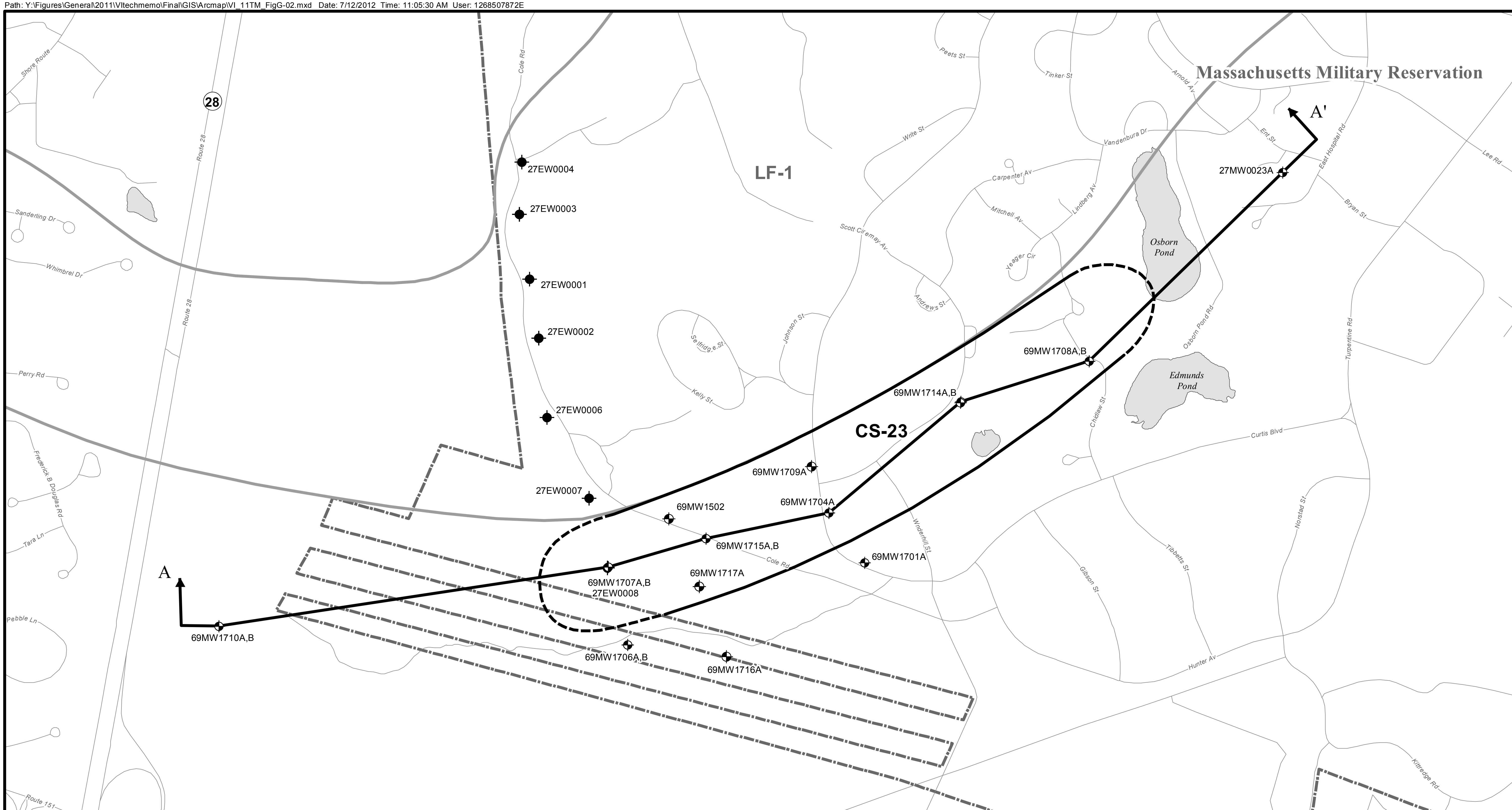
CS-23 GROUNDWATER PLUME AND REMEDIAL SYSTEM

AFCEE - Massachusetts Military Reservation

Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

CH2MHILL

Path: Y:\Figures\General\2011\VItechmemo\Final\GIS\Arcmap\VI_11TM_FigG-02.mxd Date: 7/12/2012 Time: 11:05:30 AM User: 1268507872E



Legend

- Monitoring Well
- Extraction Well
- CS-23 Plume Boundary (Dashed Where Inferred)
- Other Plume Boundary (Dashed Where Inferred)
- Massachusetts Military Reservation Boundary

Data Source: AFCEE, December 2011, MMR-AFCEE Data Warehouse
MMR Boundary from Massachusetts Air National Guard 2011

0 390 780 Feet

FIGURE G-2

CS-23 GROUNDWATER PLUME AND LOCATION OF CROSS-SECTION LINE

AFCEE - Massachusetts Military Reservation

Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

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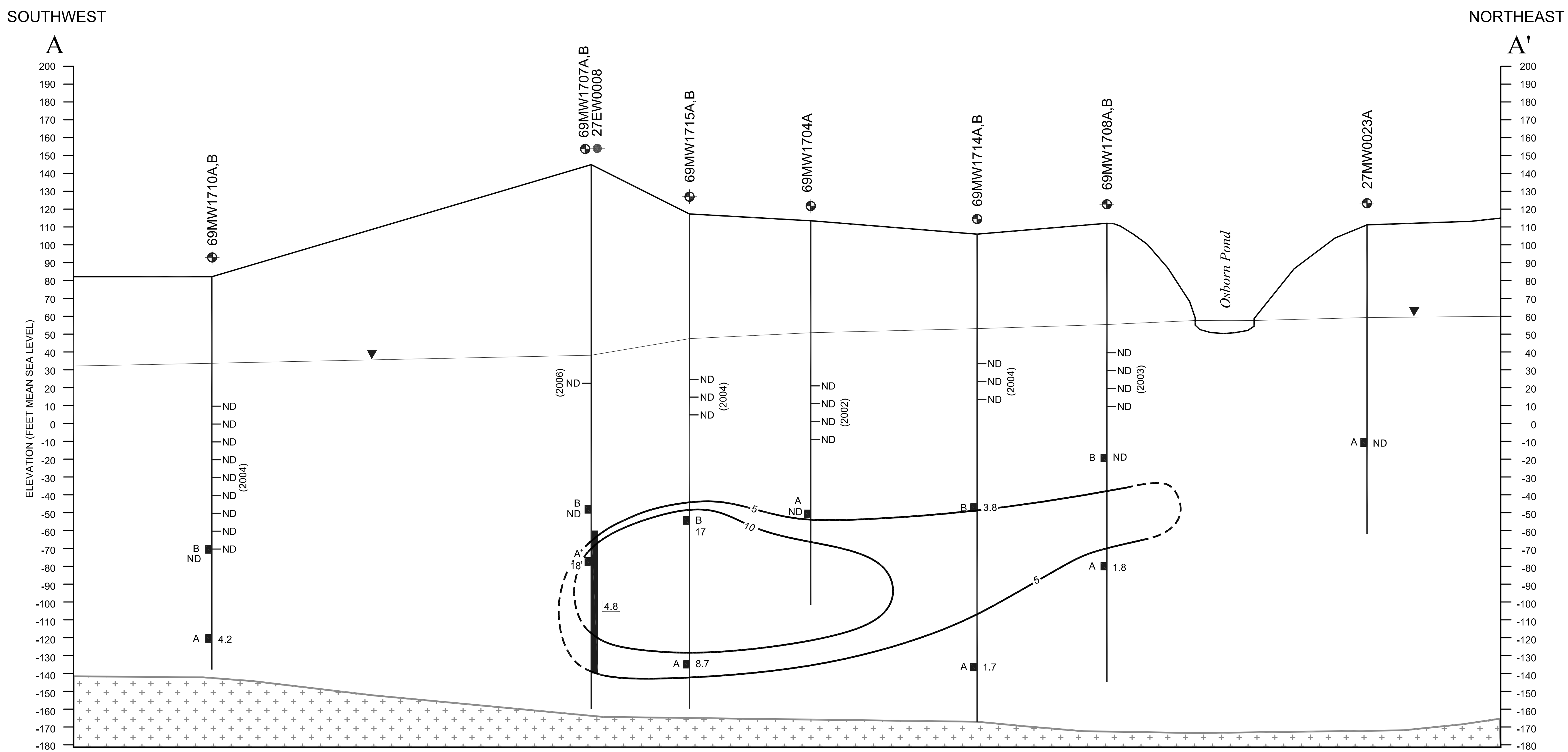

Legend

Monitoring Well
Extraction Well
Water Table
9.8 Most Recent TCE Data (μg/L) at Extraction Well
NS Not Sampled
ND Nondetect
A Well Screen ID
3.7 TCE Data (μg/L) Collected in 2011 Unless Otherwise Noted
ND TCE Vertical Profile Data (μg/L) (Date Collected)
5 2011 TCE Isoconcentration Contour (MCL = 5 μg/L) (Dashed Where Inferred)
Extraction Well Screen
Bedrock

Data Source: AFCEE, January 2012, MMR-AFCEE Data Warehouse

Notes:
1) This cross-section presents the most recent (2011 unless otherwise noted) data for the CS-23 plume.
2) Vertical profile data collected from the shallowest intervals are shown to support the VI clean water lens evaluation.

V: 60
H: 909
0 Feet

FIGURE G-3

CS-23 CROSS-SECTION A-A'

AFCEE-Massachusetts Military Reservation

Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

CH2MHILL.

Table G-1
CS-23 Groundwater Data Used in Support of VI Evaluation
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Location	Date Sampled	Mid-Sample Elevation (ft msl)	Sampling Method[1]	Result[2]
27EW0008	3/8/2006	22.51	VP	No detections of plume-related VI COPCs
27MW0023A	6/3/2011	-10.62	MW	No detections of plume-related VI COPCs
69MW1502	2/24/1998	36.24	VP	No detections of plume-related VI COPCs
69MW1502	2/24/1998	26.24	VP	No detections of plume-related VI COPCs
69MW1502	2/25/1998	16.24	VP	No detections of plume-related VI COPCs
69MW1701A	12/6/2001	15.75	VP	No detections of plume-related VI COPCs
69MW1701A	12/6/2001	5.75	VP	No detections of plume-related VI COPCs
69MW1701A	12/6/2001	-4.25	VP	No detections of plume-related VI COPCs
69MW1701A	6/2/2011	-24.75	MW	No detections of plume-related VI COPCs
69MW1704A	6/28/2002	21	VP	No detections of plume-related VI COPCs
69MW1704A	6/28/2002	11	VP	No detections of plume-related VI COPCs
69MW1704A	6/28/2002	1	VP	No detections of plume-related VI COPCs
69MW1704A	6/28/2002	-9	VP	No detections of plume-related VI COPCs
69MW1704A	4/28/2011	-50.7	MW	No detections of plume-related VI COPCs
69MW1706A	10/10/2002	11.06	VP	No detections of plume-related VI COPCs
69MW1706A	10/10/2002	1.06	VP	No detections of plume-related VI COPCs
69MW1706B	5/26/2011	-39.18	MW	No detections of plume-related VI COPCs
69MW1707B	6/2/2011	-47.68	MW	No detections of plume-related VI COPCs
69MW1708A	9/10/2003	39.57	VP	No detections of plume-related VI COPCs
69MW1708A	9/10/2003	29.57	VP	No detections of plume-related VI COPCs
69MW1708A	9/10/2003	19.57	VP	No detections of plume-related VI COPCs
69MW1708A	9/10/2003	9.57	VP	No detections of plume-related VI COPCs
69MW1708B	6/9/2011	-19.49	MW	No detections of plume-related VI COPCs
69MW1709A	9/17/2003	27.54	VP	No detections of plume-related VI COPCs
69MW1709A	9/17/2003	17.54	VP	No detections of plume-related VI COPCs
69MW1709A	9/17/2003	7.54	VP	No detections of plume-related VI COPCs
69MW1710A	4/28/2004	9.65	VP	No detections of plume-related VI COPCs
69MW1710A	4/28/2004	-0.35	VP	No detections of plume-related VI COPCs
69MW1710A	4/28/2004	-10.35	VP	No detections of plume-related VI COPCs
69MW1710A	4/28/2004	-20.35	VP	No detections of plume-related VI COPCs
69MW1710A	4/28/2004	-30.35	VP	No detections of plume-related VI COPCs
69MW1710A	4/29/2004	-40.35	VP	No detections of plume-related VI COPCs
69MW1710A	4/29/2004	-50.35	VP	No detections of plume-related VI COPCs
69MW1710A	4/29/2004	-60.35	VP	No detections of plume-related VI COPCs
69MW1710A	4/29/2004	-70.35	VP	No detections of plume-related VI COPCs
69MW1714A	4/21/2004	33.46	VP	No detections of plume-related VI COPCs
69MW1714A	4/21/2004	23.46	VP	No detections of plume-related VI COPCs
69MW1714A	4/21/2004	13.46	VP	No detections of plume-related VI COPCs
69MW1715A	4/13/2004	24.77	VP	No detections of plume-related VI COPCs
69MW1715A	4/13/2004	14.77	VP	No detections of plume-related VI COPCs
69MW1715A	4/14/2004	4.77	VP	No detections of plume-related VI COPCs
69MW1716A	1/11/2005	23.56	VP	No detections of plume-related VI COPCs
69MW1716A	1/11/2005	13.56	VP	No detections of plume-related VI COPCs
69MW1716A	1/11/2005	3.56	VP	No detections of plume-related VI COPCs
69MW1716A	1/11/2005	-6.44	VP	No detections of plume-related VI COPCs
69MW1716A	1/11/2005	-16.44	VP	No detections of plume-related VI COPCs
69MW1716A	1/12/2005	-26.44	VP	No detections of plume-related VI COPCs
69MW1716A	1/12/2005	-36.44	VP	No detections of plume-related VI COPCs

Table G-1
CS-23 Groundwater Data Used in Support of VI Evaluation
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Location	Date Sampled	Mid-Sample Elevation (ft msl)	Sampling Method[1]	Result[2]
69MW1716A	1/12/2005	-46.44	VP	No detections of plume-related VI COPCs
69MW1716A	1/12/2005	-56.44	VP	No detections of plume-related VI COPCs
69MW1717A	2/1/2005	18.87	VP	No detections of plume-related VI COPCs
69MW1717A	2/1/2005	8.87	VP	No detections of plume-related VI COPCs
69MW1717A	2/1/2005	-1.13	VP	No detections of plume-related VI COPCs
69MW1717A	2/1/2005	-11.13	VP	No detections of plume-related VI COPCs

Data Source: AFCEE, December 2011, MMR-AFCEE Data Warehouse

Notes:

1. Sample collection method:
   VP = vertical profile groundwater sampling (direct push, rotosonic, or screened hollow-stem auger drilling methods)
   MW = fixed monitoring well

2. See Table 4-1 of the main document for a complete list of VI COPCs.

The data summarized in this table specifically support the CS-23 clean water lens VI evaluation and typically include the most recent sampling results for each location for the plume-related VI COPCs only. If additional historic sampling data exist, they are available for review in the AFCEE-MMR Data Warehouse.

Vertical profile data presented only include the relevant sample intervals used to support this CS-23 VI evaluation; if analytical data from deeper sample intervals exist, they are available in the AFCEE MMR Data Warehouse.

Key:

COPC = contaminant of potential concern
CS-23 = Chemical Spill-23
ft msl = feet mean sea level
VI = vapor intrusion

Table G-2
CS-23 Well Construction and Sample Location Information
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Location	Northing (ft)	Easting (ft)	Surface Elevation (ft msl)	Measuring Point Elevation (ft msl)	Total Well Depth (ft bgs)	Top Screen Depth (ft bgs)	Bottom Screen Depth (ft bgs)	Top Screen Elevation (ft msl)	Bottom Screen Elevation (ft msl)	Screen Length (ft)
27EW0008	238229	848811	145.01	138.98	286.50	205.00	285.00	-59.99	-139.99	80
27MW0023A	241466	854329	111.18	112.06	124.30	119.30	124.30	-8.12	-13.12	5
69MW1502	238634	849306	147.49	149.34	272.00	267.50	272.00	-120.01	-124.51	5
69MW1701A	238274	850908	116.25	115.64	143.51	138.59	143.40	-22.34	-27.15	5
69MW1704A	238679	850617	113.50	113.09	166.66	161.79	166.61	-48.29	-53.11	5
69MW1706A	237600	848970	113.56	113.15	215.71	210.28	215.08	-96.72	-101.52	5
69MW1706B	237600	848970	113.56	113.15	155.78	150.34	155.13	-36.78	-41.57	5
69MW1707B	238236	848808	144.91	144.53	195.62	190.18	194.99	-45.27	-50.08	5
69MW1708A	239924	852748	112.07	111.57	194.85	189.76	194.37	-77.69	-82.30	5
69MW1708B	239924	852748	112.07	111.55	134.36	129.24	133.87	-17.17	-21.80	5
69MW1709A	239059	850472	130.04	129.64	242.67	237.23	242.18	-107.19	-112.14	5
69MW1710A	237755	845622	82.15	81.85	205.40	200.16	204.96	-118.01	-122.81	5
69MW1714A	239590	851698	105.96	105.60	244.83	239.96	244.83	-134.00	-138.87	5
69MW1715A	238469	849609	117.27	116.56	254.79	249.59	254.46	-132.32	-137.19	5
69MW1716A	237504	849777	116.06	115.64	269.50	264.16	269.16	-148.10	-153.10	5
69MW1717A	238078	849555	121.37	120.80	245.86	240.56	245.56	-119.19	-124.19	5

Data Source: AFCEE, December 2011, MMR-AFCEE Data Warehouse

Key:

bgs = below ground surface   ft = feet

CS = Chemical Spill   msl = mean sea level

APPENDIX H
FS-1 Vapor Intrusion Evaluation

TABLE OF CONTENTS

Figures

Tables

ACRONYMS AND ABBREVIATIONS

AFCEE	Air Force Center for Engineering and the Environment
bgs	below ground surface
BTEX	benzene, toluene, ethylbenzene, and xylene
COC	contaminant of concern
COPC	contaminant of potential concern
CSM	conceptual site model
EDB	ethylene dibromide
ETD	extraction, treatment and discharge
FS	Fuel Spill
ft	feet/foot
gpm	gallons per minute
MCL	Maximum Contaminant Level
MMCL	Massachusetts MCL
MMR	Massachusetts Military Reservation
msl	mean sea level
ROD	Record of Decision
SPEIM	System Performance and Ecological Impact Monitoring
SWP	shallow wellpoints
VI	vapor intrusion
VOC	volatile organic compound
µg/L	micrograms per liter

H1.0 FUEL SPILL-1 VAPOR INTRUSION EVALUATION

H1.1 FS-1 CONCEPTUAL SITE MODEL

The Fuel Spill–1 (FS-1) groundwater plume is a dilute dissolved-phase groundwater plume located southeast of the Massachusetts Military Reservation (MMR) in the Town of Mashpee, Massachusetts (Figure 1-2 of the main document). The FS-1 site contains two separate areas of groundwater contamination: the source area groundwater, which is located on the MMR below the southeast end of the flight line runway, and the FS-1 groundwater plume, which is detached from the source area and has migrated to the south. The FS-1 plume is located largely off-base, although a small portion of the plume footprint remains below on-base property (Figure H-1).

The FS-1 plume is defined as the extent of groundwater containing the primary FS-1 contaminant of concern (COC), ethylene dibromide (EDB), at concentrations greater than the Massachusetts Maximum Contaminant Level (MMCL) of 0.02 micrograms per liter (µg/L). In the source area groundwater, lead, thallium and toluene are the COCs (AFCEE 2000). Although thallium and lead are not vapor intrusion (VI) contaminants of potential concern (COPC), the petroleum hydrocarbons benzene, toluene, ethylbenzene, and xylenes (BTEX) are VI COPCs (refer to Table 4-1 in main document) that have been historically detected in source area groundwater (AFCEE 2012).

The fuel-related contamination associated with FS-1 originated from historic periodic releases of jet fuel to the ground surface from aircraft located in the Western and Eastern Aircraft Turnaround areas on the southeast end of the runway (Figure H-2). Both Aircraft Turnaround areas were investigated during the Site Investigation (ASI 1995) and Remedial Investigation (HAZWRAP 1999). No significant concentrations of contaminants were detected in the surface or subsurface soils at the FS-1 source area (AFCEE 2000).

The BTEX groundwater contamination at concentrations above Maximum Contaminant Levels (MCL) associated with the FS-1 source area was located at or near the water table below on-base areas within approximately 1,000 feet (ft) of the runways. BTEX compounds have historically been detected in the FS-1 plume, although only sporadically and at very low concentrations

(AFCEE 2012). Based on the last round of source area groundwater monitoring for BTEX compounds conducted in 2004, no BTEX compounds were detected above their respective MCLs.

A plan view of the FS-1 plume, along with the location of the line of cross-section and monitoring locations used to support this VI evaluation, are shown on Figure H-2. A north-south cross-sectional view of the FS-1 plume is provided as Figure H-3.

The most recent depiction of the FS-1 plume boundary (based on data collected through 2011), shows that the FS-1 plume has migrated from the source area below undeveloped property in the Town of Mashpee. The only buildings or structures present within the vicinity of the plume footprint are the FS-1 treatment plant, former shallow wellpoint pump house, and a former bog pump house building in the center of the bog complex (Figure H-1). The main body of the FS-1 plume is approximately 3,500 ft long, up to 700 ft wide, and is approximately 95 ft thick and located in the deeper portion of the aquifer. Characteristic of many of the MMR groundwater plumes, the FS-1 plume descended in the aquifer as it migrated from its source area due to recharge accretion, resulting in the plume being located relatively deep in the aquifer and entirely overlain by a lens of clean groundwater. The upper boundary of the FS-1 plume is over 145 ft below ground surface (bgs) and over 80 ft below the water table (Figure H-3).

The topography of the land above the FS-1 plume is generally flat but slightly undulating with a regional ground elevation change of approximately 70 ft from north to south. Sub-regionally, the area is characterized by low rolling hills and flat areas of the Mashpee Pitted Plain, which is a broad, flat, gently southward-sloping glacial outwash plain. Within the footprint of the plume, the maximum and minimum ground surface elevations are approximately 105 ft mean sea level (msl), and 35 ft msl, respectively (AFCEE 2012).

The groundwater flow direction in the vicinity of the northern portion of the FS-1 plume is generally to the south-southeast and transitions to the south-southwest dowgradient due to the hydraulic influence of the Quashnet River and bog network. The flow within the aquifer is primarily horizontal; however, the potential for a stronger component of vertical flow exists near the river and bogs. The depth to groundwater in the vicinity of the FS-1 plume ranges from less

than a few feet near the river and bogs to approximately 60 ft bgs at the main plume body and approximately 50 ft bgs below the source area. The elevation of the water table ranges from approximately 60 ft msl at the source area to approximately 30 ft msl near the downgradient edge of the plume. The aquifer saturated thickness in the FS-1 area ranges from approximately 240 to 280 ft (AFCEE 2012).

The FS-1 extraction, treatment, and discharge (ETD) pilot system operated between 05 April 1999 and 13 October 2002, when a fire destroyed the treatment plant. The pilot ETD system was located in the southern portion of the plume and consisted of one deep extraction well (36EW0005) and 175 shallow wellpoints (SWP) that operated at a combined extraction rate of 750 gallons per minute (gpm). The pilot ETD system was replaced with the final FS-1 ETD system which became operational on 30 September 2003 at a design flow rate of 750 gpm. The final ETD system consists of four deep extraction wells (36EW0001, 36EW0005, 36EW0007, and 36EW0011) located in the south-central portion of the plume. The SWP system was decommissioned in November 2003 and the SWP pump house was turned over to the Town of Mashpee. The extracted groundwater is treated through granular activated carbon at the FS-1 treatment plant, and the treated water is discharged to surface water through three vertical riser pipes (outflow bubblers). The Air Force Center for Engineering and the Environment (AFCEE) installed the final FS-1 ETD system under a Final Record of Decision (ROD) that specified active treatment for the FS-1 plume. The final ETD system design was detailed in the *Final Fuel Spill-1 Wellfield Design Report* (AFCEE 2001). The ongoing remedial actions at FS-1 are managed under the System Performance and Ecological Impact Monitoring (SPEIM) program. Since startup in 2003, the final FS-1 ETD system has been optimized several times, and is currently operating under pumping configuration 2007 Scenario 01, which has a total flow rate of 515 gpm from three operating extraction wells (AFCEE 2012). Groundwater transport modeling using the FS-1 2006 EDB plume shell and pumping configuration 2007 Scenario 01 predicts that the ETD system will continue to effectively capture the EDB plume until approximately 2020. After that time a small pod of low concentration EDB contamination is predicted to remain in low hydraulic conductivity aquifer materials through approximately 2031 (AFCEE 2011).

H1.2 STEP 1: CLEAN WATER LENS

As established in Section 4.1.1 and depicted graphically in Figure 4-1 of the main document, the first step in evaluating the possibility of VI for a groundwater plume is determining whether a continuous 3-ft-thick clean water lens is present above the entire plume and is expected to remain for the foreseeable future as long as the plume exists. If the evaluation indicates that a clean water lens is present using the criteria presented in Section 4.1.1 of the main document, it can be concluded that the VI pathway is incomplete and no further evaluation is required.

The clean water lens evaluation for the detached FS-1 groundwater plume included a review of the analytical data for the primary FS-1 COC (EDB). In the source area, other plume-related volatile organic compound (VOC) data were reviewed (i.e., for BTEX compounds), as included in the list of VI COPCs in Table 4-1 of the main document. For this FS-1 VI evaluation, the absence of plume-related VOC detections in groundwater at the water table below the source area defines the presence of a clean water lens. For the FS-1 plume, the presence of a clean water lens is defined using the available EDB analytical data.

The following subsections evaluate the clean water lens at the two FS-1 areas of concern; the detached FS-1 plume largely located off base; and the shallow groundwater associated with the on-base source area that contains residual concentrations of BTEX compounds.

H1.2.1 FS-1 Groundwater Plume

The locations of all the monitoring points used for the FS-1 VI evaluation are shown on Figure H-2. The most recent EDB data used are shown on the north-south cross-sectional depiction of the plume on Figure H-3. The supporting analytical data are summarized in Table H-1. Well construction and sampling location information is included in Table H-2.

As described in the conceptual site model (CSM) in Section H1.1, the most recent monitoring data indicate that the FS-1 plume is located deep in the aquifer. Characterization data collected under the SPEIM program confirm that the FS-1 plume is overlain by a substantial thickness of clean water well in excess of 3 ft. The data that support this aspect of the CSM are as follows:

- Groundwater vertical profile data collected in 2010 at sample elevations above the FS-1 plume at 36DP0101, 36DP0102, and 36DP0103 indicate the presence of at least a 70 ft thickness of clean water above the plume. In addition, monitoring data collected at 36PZ1001 and 36PZ1002B in 2011 (Figure H-2) confirm the absence of EDB at or near the water table at the southernmost extent of the plume. Wells 36PZ1001 and 36PZ1002B used to be within the plume footprint, but are now all located outside of the plume boundary; however, the data collected at these locations are helpful in demonstrating that EDB is not present at the water table in this area.
- Groundwater vertical profile data collected at sample elevations above the main body of the FS-1 plume at 36MW1041A in 2000 and 36MW1043A in 2002 support the presence of at least a 60 ft thickness of clean water above the plume.
- Monitoring data collected in 2011 at the following wells screened above the FS-1 plume were used to confirm the presence of a clean water lens greater than 3 ft: 36MW0132B, 36MW0132C, 36MW1041B, and 36MW1041C.

In summary, characterization and monitoring data from multiple locations throughout the area of the FS-1 plume confirm the presence of a clean water lens overlying the entire plume well in excess of the 3 ft thickness criterion used for this VI screening evaluation. It is acknowledged, however, that some of these characterization data are not recent (i.e., dating back to 2000 in some cases). But when combined with more recent data collected in 2010 and 2011 and the overall understanding of the hydrogeologic aspect of the CSM, they still provide sound lines of evidence that the FS-1 plume is located deep in the aquifer and is overlain by a substantial thickness of clean water. Furthermore, given the substantial thickness of clean water above the entire plume and the ongoing remedial actions, a change in the clean water lens presence is not anticipated in the future.

H1.2.2 Source Area Groundwater

The latest available VOC monitoring data collected in 2004 at wells in the source area (36MW0002, 36MW0007, and 36MW0008) which are all screened at or near the water table indicate that detectable concentrations of toluene, ethylbenzene, and/or xylene were present in groundwater at the water table at that time (Figure H-2 and Table H-1). Therefore, a clean water lens cannot be demonstrated below the FS-1 source area using existing data and a complete VI pathway cannot be ruled out. Further VI evaluation (i.e., Step 2 of the VI evaluation process) is warranted for the FS-1 source area.

H1.3 STEP 2: BUILDINGS AND PREFERENTIAL AIRFLOW PATHWAYS

If it is determined that a constant 3-ft-thick lens of clean water does not exist or its presence cannot be demonstrated with an adequate level of certainty, the next step in a VI assessment is the evaluation of the proximity of potential receptors (Section 4.1.2 of main document). This is only necessary for the source area groundwater at FS-1.

H1.3.1 Source Area

The extent of VI COPC (toluene, ethylbenzene, and/or xylene) detections in monitoring wells screened at or near the water table is shown on Figure H-4. As illustrated on this figure, the detections are limited to wells that are located on-base and in the immediate vicinity of the Western Aircraft Turnaround area (Figure H-2). The land above the FS-1 source area is largely undeveloped and there are no buildings or structures located within 100 ft of the monitoring wells where residual detections remain (Figure H-4). In addition, based on consultation with, and a review of plans provided by, the base 102nd Civil Engineering Squadron, there are no known underground utilities that could act as preferential airflow pathways within 100 ft of these wells (Department of the Air Force 1962).

Since the FS-1 source area is located on the MMR, future development, including the construction of new buildings in this area, is controlled through institutional controls specified in the FS-1 ROD (AFCEE 2000). Specifically, the Air National Guard has administrative processes and procedures that require approval for all projects involving construction or digging/subsurface soil disturbance at the MMR. In the event construction activities were planned in the FS-1 source area, the Installation Restoration Program would take appropriate measures to address VI concerns as they relate to any future structures and/or underground utilities or other potential preferential airflow pathways.

H2.0 CONCLUSIONS AND RECOMMENDATIONS

H2.1 CONCLUSIONS

A review of groundwater characterization and monitoring data collected at FS-1 indicates that a continuous clean water lens at least 3 ft thick is present above the entire body of the FS-1 EDB plume and is expected to be present in the future as long as the plume exists. Due to the presence of a substantial clean water lens overlying the entire extent of the FS-1 EDB plume, and the ongoing active treatment to control its migration, the VI pathway is considered incomplete in this area. However, residual concentrations of toluene, ethylbenzene, and xylene are present at the water table below the FS-1 source area (located on-base). Although a clean water lens may not exist below the FS-1 source area, no buildings, structures, or preferential airflow pathways are located in this area and future site development is controlled by on-base entities. Therefore, the VI exposure pathway at FS-1 is considered incomplete due to the absence of nearby receptors.

H2.2 RECOMMENDATIONS

No further monitoring or data collection is needed specific to VI. However, as part of the ongoing remedial actions at FS-1, AFCEE will continue to monitor the nature and extent of the FS-1 EDB plume under the SPEIM program and the residual toluene, ethylbenzene, and xylene concentrations at the source area will be further evaluated during site closure activities. The VI exposure pathway will be re-evaluated if conditions change such that VI could become a concern.

H3.0 REFERENCES

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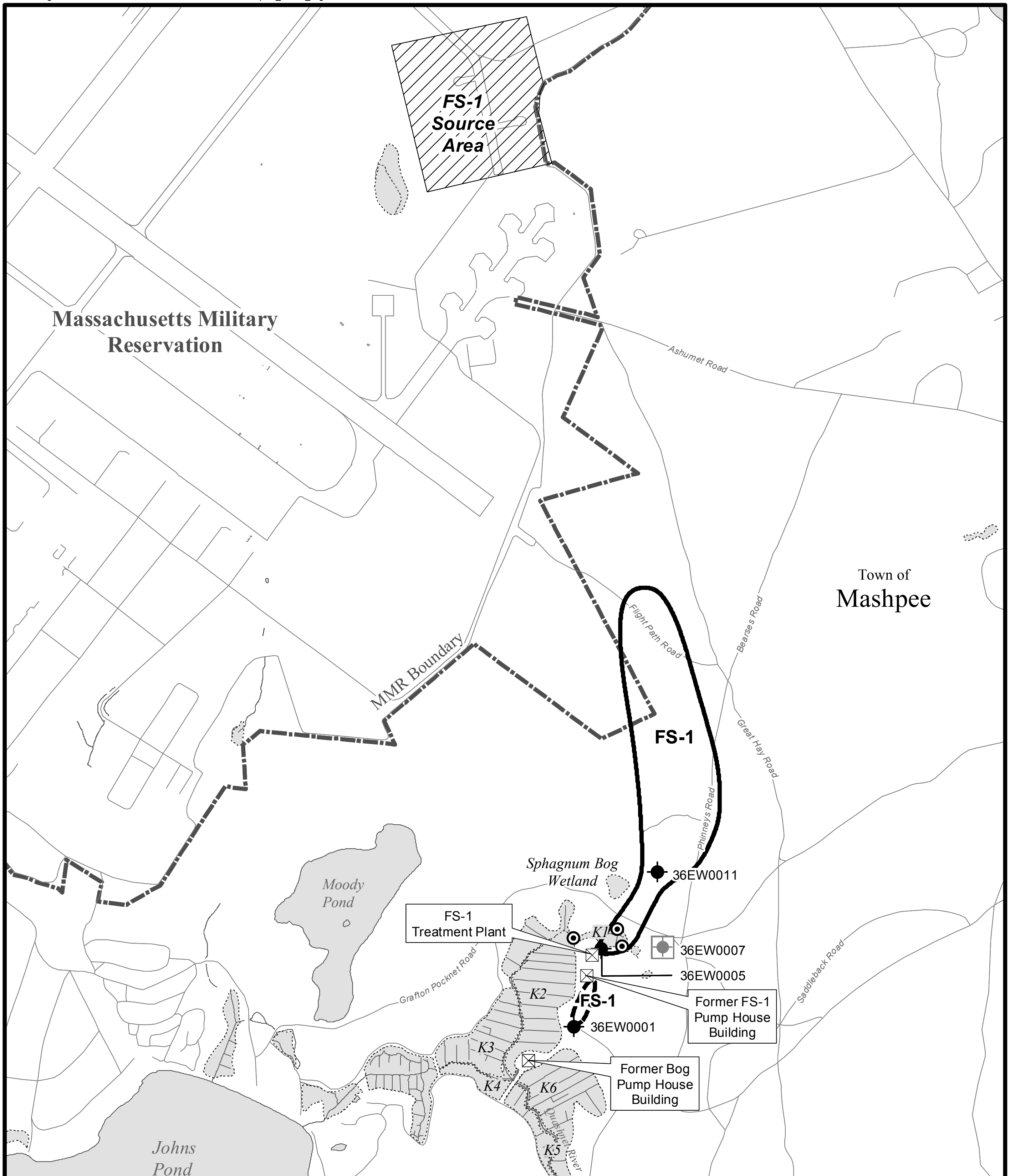


Legend

Data Source: AFCEE, February 2012, MMR-AFCEE Data Warehouse
MMR Boundary from Massachusetts Air National Guard 2011

- Outflow Bubbler
- Extraction Well (On)
- Extraction Well (Off)
- Treatment Plant
- Massachusetts Military Reservation Boundary
- Plume Boundary (Dashed Where Inferred)
- Bog/Wetland
- Source Area

N

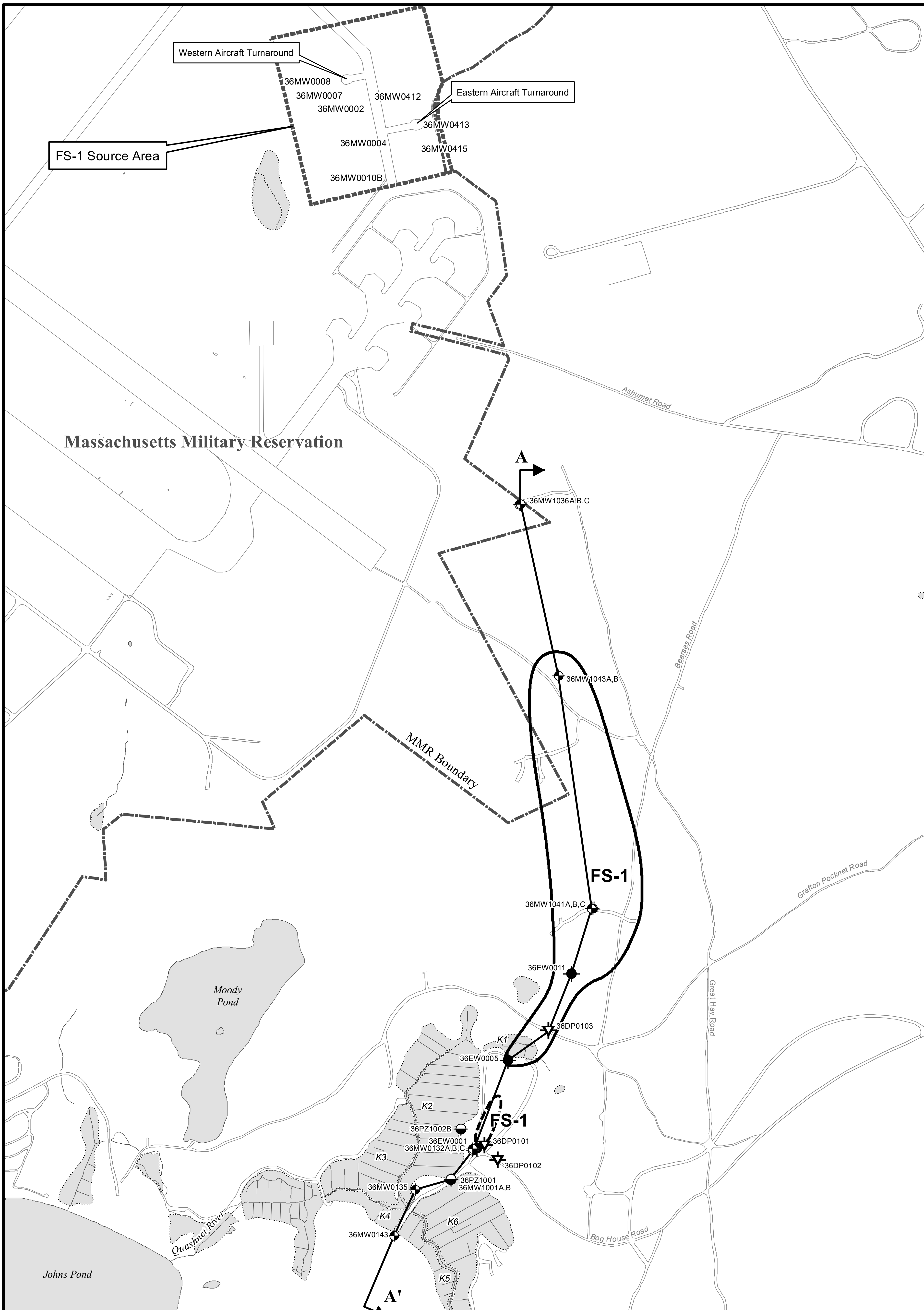
0 600 1,200 Feet

FIGURE H-1

FS-1 GROUNDWATER PLUME AND REMEDIAL SYSTEM

AFCEE - Massachusetts Military Reservation
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

CH2MHILL



Legend

- Extraction Well
- Monitoring Well
- Piezometer
- Direct Push
- Sonic Locations
- Massachusetts Military Reservation Boundary
- Plume Boundary (Dashed Where Inferred)
- A' Cross-Section Line
- Bog/Wetland

Data Source: AFCEE, February 2012, MMR-AFCEE Data Warehouse
MMR Boundary from Massachusetts Air National Guard 2011

N

0 370 740 Feet

FIGURE H-2

FS-1 GROUNDWATER PLUME AND LOCATION OF CROSS-SECTION LINE

AFCEE - Massachusetts Military Reservation

Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

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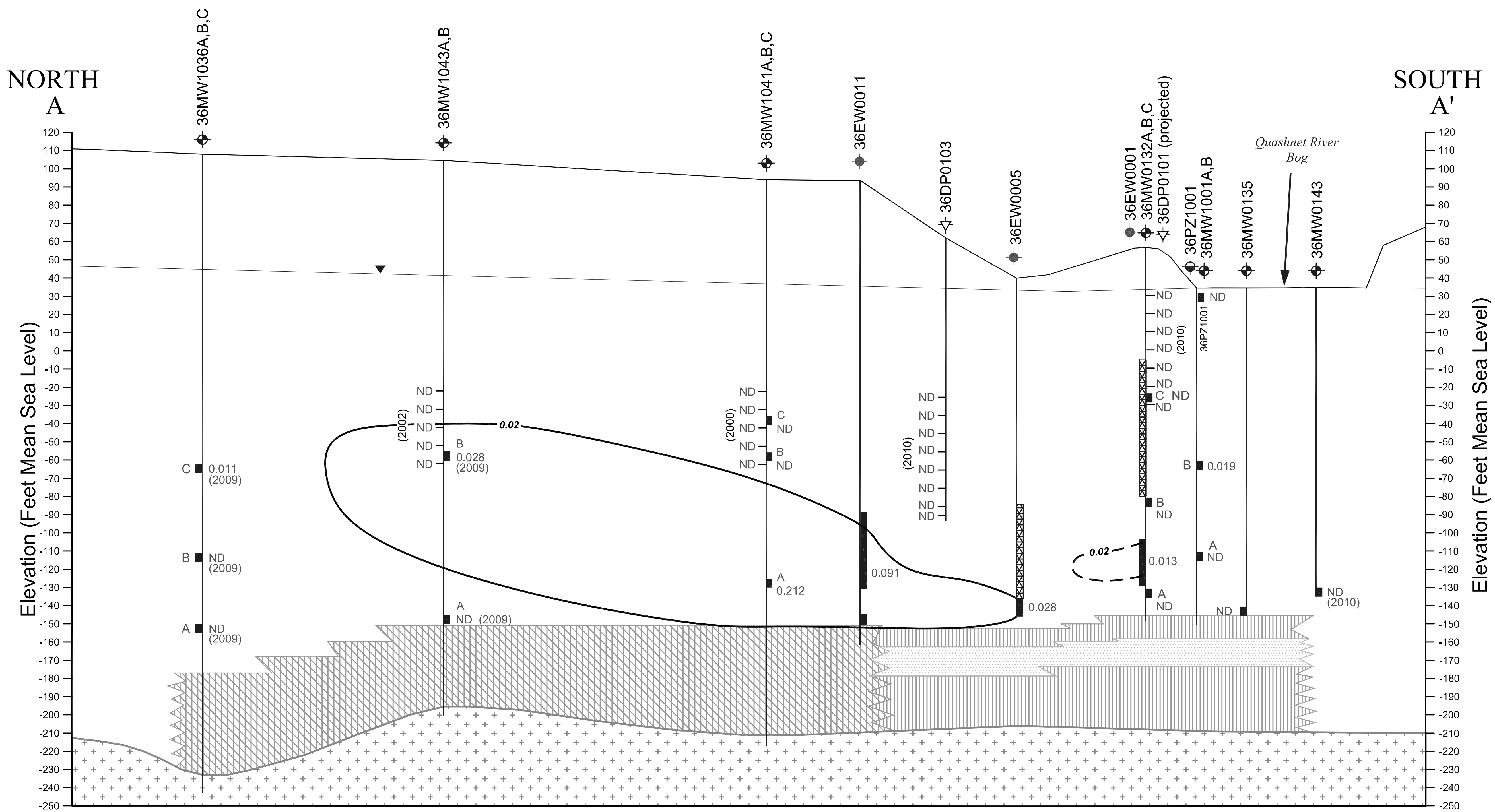

Legend

- Monitoring Well
- Piezometer
- Extraction Well
- Direct Push
- Water Table
- 0.02 EDB Isoconcentration Contour (Dashed Where Inferred)
- Screen Closed (Packered)
- A Well Screen
- ND Nondetect
- (2002) ND EDB Vertical Profile Data (µg/L) (Date Collected)
- 0.011 EDB Result from June 2011, unless otherwise noted (µg/L)
- Silt
- Fine Sand
- Bedrock
- Silty Clay

Data Source: February 2012, AFCEE, MMR-AFCEE Data Warehouse

Notes:
1. This cross-section presents the most recent data (2011 unless otherwise noted) for the FS-1 plume.
2. Vertical profile data from the shallowest intervals are shown to support the VI clean water lens evaluation.

V: 60
H: 600
0 Feet

FIGURE H-3

FS-1 CROSS-SECTION A-A'

AFCEE - Massachusetts Military Reservation

Final 2011 MMR Vapor Intrusion Evaulation Technical Memorandum

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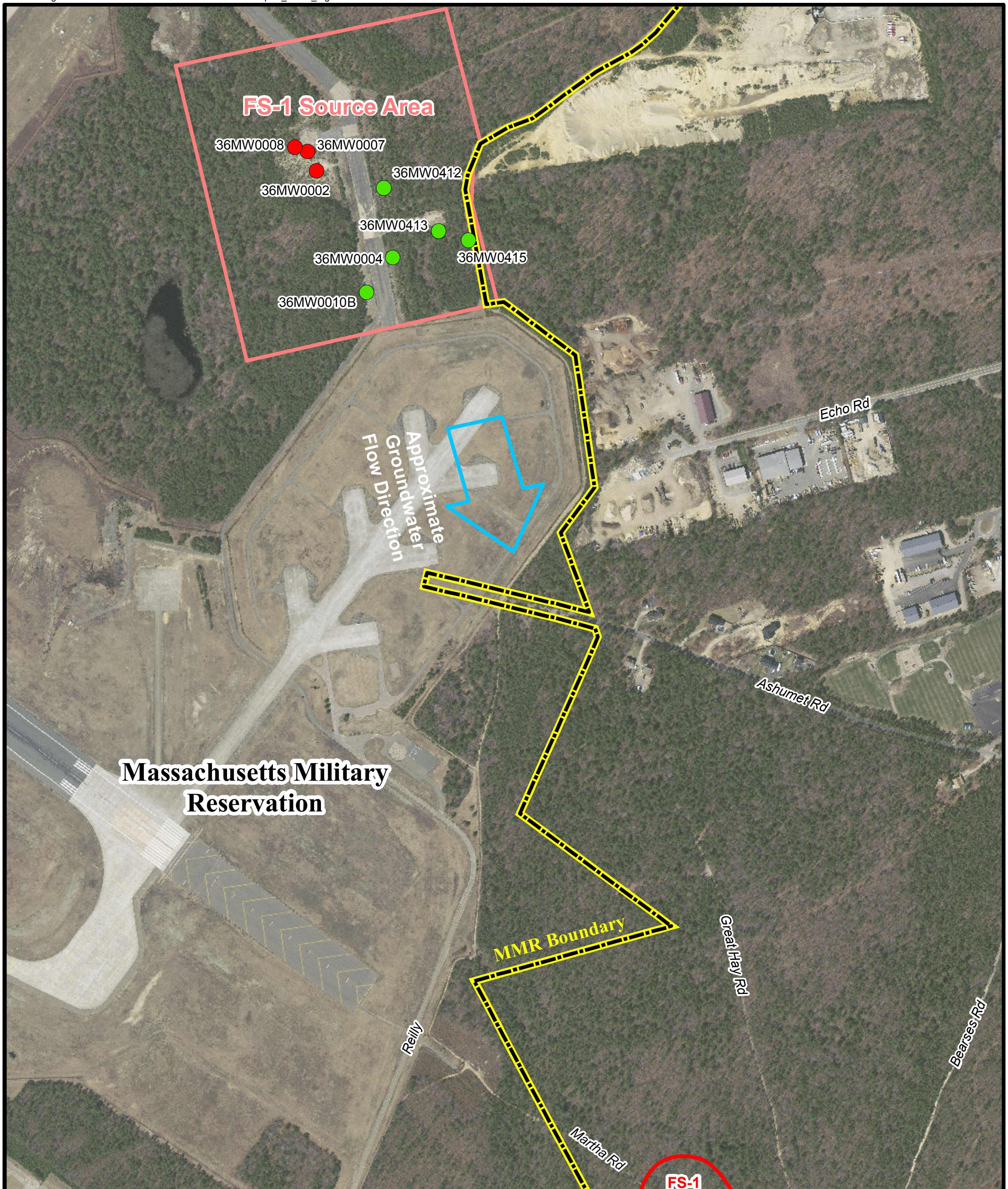

Legend

- Massachusetts Military Reservation Boundary
- Plume Boundary
- Plume Source Area Boundary
- Monitoring Well - VI COPC Detected
- Monitoring Well - VI COPC Not Detected

Data Source: AFCEE, MMR-AFCEE Data Warehouse
MMR Boundary from Massachusetts Air National Guard 2011
2009 Aerial Photography from MassGIS

FIGURE H-4

FS-1 SOURCE AREA EXTENT OF WATER TABLE VI COPC DETECTIONS

AFCEE - Massachusetts Military Reservation

Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

CH2MHILL

Table H-1
FS-1 Groundwater Data Used in Support of VI Evaluation
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Location	Date Sampled	Mid-Sample Elevation (ft msl)	Sampling Method[1]	VI COPC[2]	Result (µg/L)
FS-1 Groundwater Plume					
36DP0101	5/18/2010	30.5	VP	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
36DP0101	5/18/2010	20.5	VP	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
36DP0101	5/18/2010	10.5	VP	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
36DP0101	5/18/2010	0.5	VP	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
36DP0101	5/18/2010	-9.5	VP	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
36DP0101	5/18/2010	-19.5	VP	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
36DP0101	5/19/2010	-29.5	VP	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
36DP0102	5/21/2010	29.5	VP	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
36DP0102	5/21/2010	19.5	VP	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
36DP0102	5/21/2010	9.5	VP	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
36DP0102	5/21/2010	-0.5	VP	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
36DP0102	5/25/2010	-10.5	VP	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
36DP0102	5/25/2010	-20.5	VP	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
36DP0102	5/25/2010	-30.5	VP	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
36DP0102	5/25/2010	-38.7	VP	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
36DP0102	5/26/2010	-48.7	VP	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
36DP0102	5/26/2010	-55.0	VP	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
36DP0103	6/1/2010	-25.5	VP	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
36DP0103	6/1/2010	-35.5	VP	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
36DP0103	6/1/2010	-45.5	VP	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
36DP0103	6/1/2010	-55.5	VP	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
36DP0103	6/1/2010	-65.5	VP	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
36DP0103	6/1/2010	-75.5	VP	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
36DP0103	6/1/2010	-85.5	VP	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
36DP0103	6/1/2010	-90.5	VP	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
36MW0132B	6/24/2011	-83.2	MW	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
36MW0132C	6/24/2011	-25.89	MW	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
36MW1041A	8/22/2000	22.38	VP	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
36MW1041A	8/22/2000	12.38	VP	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
36MW1041A	8/22/2000	2.38	VP	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
36MW1041A	8/22/2000	-7.62	VP	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
36MW1041A	8/22/2000	-27.62	VP	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
36MW1041B	6/22/2011	-58.3	MW	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
36MW1041C	6/22/2011	-38.3	MW	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
36MW1043A	5/14/2002	22.08	VP	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
36MW1043A	5/14/2002	12.08	VP	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
36MW1043A	5/14/2002	2.08	VP	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
36MW1043A	5/14/2002	-7.92	VP	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
36MW1043A	5/14/2002	-17.92	VP	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
36PZ1001	6/24/2011	29.4	MW	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
36PZ1002B	6/24/2011	29.2	MW	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
FS-1 Source Area Groundwater					
36MW0002	11/22/2004	54.29	MW	BENZENE	ND
36MW0002	11/22/2004	54.29	MW	ETHYLBENZENE	79.6
36MW0002	11/22/2004	54.29	MW	M,P-XYLENE (SUM OF ISOMERS)	101
36MW0002	11/22/2004	54.29	MW	O-XYLENE (1,2-DIMETHYLBENZENE)	26.7
36MW0002	11/22/2004	54.29	MW	TOLUENE	BRL

Table H-1
FS-1 Groundwater Data Used in Support of VI Evaluation
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Location	Date Sampled	Mid-Sample Elevation (ft msl)	Sampling Method[1]	VI COPC[2]	Result (µg/L)
36MW0004	4/22/1999	40.51	MW	BENZENE	ND
36MW0004	4/22/1999	40.51	MW	ETHYLBENZENE	ND
36MW0004	4/22/1999	40.51	MW	TOLUENE	ND
36MW0004	4/22/1999	40.51	MW	XYLENES, TOTAL	ND
36MW0007	11/22/2004	56.2	MW	BENZENE	ND
36MW0007	11/22/2004	56.2	MW	ETHYLBENZENE	42
36MW0007	11/22/2004	56.2	MW	M,P-XYLENE (SUM OF ISOMERS)	47.5
36MW0007	11/22/2004	56.2	MW	O-XYLENE (1,2-DIMETHYLBENZENE)	BRL
36MW0007	11/22/2004	56.2	MW	TOLUENE	ND
36MW0008	4/22/1999	55.7	MW	BENZENE	ND
36MW0008	4/22/1999	55.7	MW	ETHYLBENZENE	56
36MW0008	4/22/1999	55.7	MW	TOLUENE	ND
36MW0008	4/22/1999	55.7	MW	XYLENES, TOTAL	130
36MW0010B	4/22/1999	45.6	MW	BENZENE	ND
36MW0010B	4/22/1999	45.6	MW	ETHYLBENZENE	ND
36MW0010B	4/22/1999	45.6	MW	TOLUENE	ND
36MW0010B	4/22/1999	45.6	MW	XYLENES, TOTAL	ND
36MW0412	4/23/1999	55.0	MW	BENZENE	ND
36MW0412	4/23/1999	55.0	MW	ETHYLBENZENE	ND
36MW0412	4/23/1999	55.0	MW	TOLUENE	ND
36MW0412	4/23/1999	55.0	MW	XYLENES, TOTAL	ND
36MW0413	4/23/1999	55.2	MW	BENZENE	ND
36MW0413	4/23/1999	55.2	MW	ETHYLBENZENE	ND
36MW0413	4/23/1999	55.2	MW	TOLUENE	ND
36MW0413	4/23/1999	55.2	MW	XYLENES, TOTAL	ND
36MW0415	4/23/1999	52.3	MW	BENZENE	ND
36MW0415	4/23/1999	52.3	MW	ETHYLBENZENE	ND
36MW0415	4/23/1999	52.3	MW	TOLUENE	ND
36MW0415	4/23/1999	52.3	MW	XYLENES, TOTAL	ND

Data Source: AFCEE, February 2012, MMR-AFCEE Data Warehouse

Notes:

1. Sample collection method:
   VP = vertical profile groundwater sampling (direct push, rotosonic, or screened hollow-stem auger drilling methods)
   MW = fixed monitoring well
2. See Table 4-1 of the main document for a complete list of VI COPCs.

The data summarized in this table specifically support the FS-1 clean water lens VI evaluation and typically include the most recent sampling results for each location for the plume-related VI COPCs only. If additional historic sampling data exist, they are available for review in the AFCEE-MMR Data Warehouse.

Vertical profile data presented only include the relevant sample intervals used to support this FS-1 VI evaluation; if analytical data from deeper sample intervals exist, they are available in the AFCEE MMR Data Warehouse.

Key:

BRL = below reporting limit
COPC = contaminant of potential concern
ft msl = feet mean sea level
FS-1 = Fuel Spill-1
ND = not detected
VI = vapor intrusion
µg/L = micrograms per liter

Table H-2
FS-1 Well Construction and Sample Location Information
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Location	Northing (ft)	Easting (ft)	Surface Elevation (ft msl)	Measuring Point Elevation (ft msl)	Total Well Depth (ft bgs)	Top Screen Depth (ft bgs)	Bottom Screen Depth (ft bgs)	Top Screen Elevation (ft msl)	Bottom Screen Elevation (ft msl)	Screen Length (ft)
36DP0101	233953	871841	58	NA	NA	NA	NA	NA	NA	NA
36DP0102	233844	871941	57	NA	NA	NA	NA	NA	NA	NA
36DP0103	234817	872322	62	NA	NA	NA	NA	NA	NA	NA
36MW0002	241852	870832	106	108.75	56	46.46	56.46	59.29	49.29	10
36MW0004	241485	871155	112	113.51	76	66.00	76.00	45.51	35.51	10
36MW0007	241934	870793	107	110.14	56	46.00	56.00	61.20	51.20	10
36MW0008	241953	870741	107	109.75	56	46.00	56.00	60.70	50.70	10
36MW0010B	241336	871045	108	111.20	65	60.00	65.00	48.10	43.10	5
36MW0132B	233922	871754	54	53.96	140	135.00	140.00	-80.70	-85.70	5
36MW0132C	233936	871754	55	53.98	83	78.00	83.00	-23.39	-28.39	5
36MW0412	241781	871116	108	110.70	58	47.60	57.60	60.00	50.00	10
36MW0413	241597	871349	109	110.48	59	48.50	58.50	60.20	50.20	10
36MW0415	241559	871477	116	117.49	69	58.60	68.60	57.30	47.30	10
36MW1041A	235745	872659	94	93.12	224	219.10	223.90	-125.22	-130.02	5
36MW1041B	235745	872650	94	93.52	155	149.70	154.60	-55.75	-60.65	5
36MW1041C	235745	872650	94	93.51	135	129.80	134.70	-35.85	-40.75	5
36MW1043A	237500	872399	105	104.23	255	249.98	254.77	-145.40	-150.19	5
36PZ1001	233707	871589	34	33.36	7	2.00	7.00	31.90	26.90	5
36PZ1002B	234086	871664	34	33.62	7	2.00	7.00	31.74	26.74	5

Data Source: AFCEE, February 2012, MMR-AFCEE Data Warehouse

Key:

bgs = below ground surface

FS-1 = Fuel Spill-1

ft = feet

msl = mean sea level

NA = data not available; locations are direct push vertical profile borings and have no permanent screens installed.

APPENDIX I

FS-12 Vapor Intrusion Evaluation

TABLE OF CONTENTS

Figures

Tables

ACRONYMS AND ABBREVIATIONS

AFCEE	Air Force Center for Engineering and the Environment
bgs	below ground surface
BTEX	benzene, toluene, ethylbenzene, and xylene
COC	contaminant of concern
COPC	contaminant of potential concern
CSM	conceptual site model
EDB	ethylene dibromide
FS	Fuel Spill
ft	feet/foot
gpm	gallons per minute
MCL	Maximum Contaminant Level
MMCL	Massachusetts MCL
MMR	Massachusetts Military Reservation
msl	mean sea level
ROD	Record of Decision
SPEIM	System Performance and Ecological Impact Monitoring
VI	vapor intrusion
VOC	volatile organic compound
μg/L	micrograms per liter

I1.0 FUEL SPILL-12 VAPOR INTRUSION EVALUATION

I1.1 FS-12 CONCEPTUAL SITE MODEL

The Fuel Spill–12 (FS-12) groundwater plume is a dilute dissolved-phase groundwater plume located outside the eastern boundary of the Massachusetts Military Reservation (MMR) in Sandwich, Massachusetts (Figure 1-2 of main document) and is detached from its source area. The FS-12 plume (Figure I-1) is currently defined as the extent of groundwater containing the primary groundwater contaminant of concern (COC), ethylene dibromide (EDB), at concentrations greater than the Massachusetts Maximum Contaminant Level (MMCL) of 0.02 micrograms per liter (µg/L). Benzene is also a COC for the FS-12 plume; however, detections higher than the Maximum Contaminant Level (MCL) of 5 µg/L have not been observed since 2006 (AFCEE 2010).

The source area for the FS-12 plume is located on the MMR below Greenway Road (Figure I-1) and was the result of a break in an underground fuel pipeline that was discovered in 1970. The pipeline, which ran below the edge of Greenway Road in the area of the release, was constructed of 4-inch steel and extended approximately 12 miles generally north to south from a fuel transfer facility located on the Cape Cod Canal in Sandwich to the MMR fuel storage site. The pipeline carried Jet Propulsion-4 and aviation gasoline. The FS-12 source area consisted of approximately 11 acres of contaminated soil, groundwater, and floating free product. This source area contamination was treated using a soil vapor extraction system between 1995 and 1998 (AFCEE 2010). The source area groundwater is currently characterized by the presence of benzene, toluene, ethylbenzene, and xylene (BTEX) compounds, which are vapor intrusion (VI) contaminants of potential concern (COPC). No free product remains, and neither EDB nor other volatile petroleum hydrocarbons are detected in shallow groundwater below the source area. Monitoring data confirm that the residual levels of BTEX detections in FS-12 source area groundwater are not acting as an ongoing source to downgradient groundwater contamination (AFCEE 2010). Furthermore, the FS-12 source area is no longer routinely monitored for volatile organic compounds (VOCs) since the concentrations of BTEX compounds at monitoring wells in the source area have decreased below applicable MCLs and are expected to continue to decrease with time (AFCEE 2011a).

A plan view of the FS-12 EDB plume, along with the location of the lines of cross-section and monitoring locations used to support this VI evaluation, are shown on Figure I-2. Cross-sectional views of the FS-12 plume are provided as Figures I-3 and I-4. Note that the plume boundary shown on Figures I-1 and I-2 is based on data collected in 2010, whereas the depiction of the plume shown in cross-sectional view on Figures I-3 and I-4 is based on data collected in 2011.

The FS-12 EDB plume has migrated from the source and is now located entirely off-base under private property (known as Camp Good News) located northeast of Snake Pond in the Town of Sandwich (Figure I-1). Buildings and structures do exist on this property and consist of seasonal cabins, a dining hall, a recreation building, and administrative buildings. The footprint of the FS-12 plume is confined to Camp Good News property and is approximately 2,200 feet (ft) long, up to 1,250 ft wide, and is approximately 50 ft thick in the deeper portion of the aquifer. Characteristic of many of the MMR groundwater plumes, the FS-12 plume descended in the aquifer as it migrated from its source area due to recharge accretion, resulting in the plume being located relatively deep in the aquifer and entirely overlain by a lens of clean groundwater. The upper boundary of the FS-12 plume is over 95 ft below ground surface (bgs) and over 70 ft below the water table (Figures I-3 and I-4).

The topography of the land above the FS-12 plume footprint is generally flat but slightly undulating with a ground elevation change of approximately 65 ft within the footprint of the plume. Sub-regionally, the area is characterized by low rolling hills and flat areas of the Mashpee Pitted Plain, which is a broad, flat, gently southward-sloping glacial outwash plain. Within the footprint of the plume, the maximum and minimum ground surface elevations are approximately 150 ft mean sea level (msl), and 85 ft msl, respectively (AFCEE 2010).

The groundwater flow direction in the vicinity of the FS-12 plume is generally to the south-southeast and flow within the aquifer is primarily horizontal. The depth to groundwater above the FS-12 plume ranges from a few feet near Snake Pond to approximately 80 ft bgs within the main plume body to 90 ft bgs below the source area to the north. The elevation of the water table is approximately 75 ft msl below the source area and approximately 70 ft msl at the

plume's southern extent, indicating a very low hydraulic gradient. The aquifer saturated thickness in the FS-12 area ranges from approximately 200 to 240 ft (AFCEE 2010).

The FS-12 groundwater remedial system was installed as an interim remedial action and became operational in 1997. Initially, 25 extraction wells were used to capture the FS-12 plume, which were arranged across the toe of the southern extent of the FS-12 plume and in an axial arrangement designed to remediate the central portion of the plume where the highest contaminant concentrations were located. At startup, the system operated at an original design flow rate of 772 gallons per minute (gpm). In 2006, the Air Force Center for Engineering and the Environment (AFCEE) issued a Record of Decision (ROD), which specified the continued operation of the FS-12 remedial system as the final remedy for groundwater. The objective of the alternative selected in the ROD was plume capture and containment (AFCEE 2006).

The ongoing remedial actions at FS-12 are managed under the System Performance and Ecological Impact Monitoring (SPEIM) program. Since startup in 1997, the FS-12 system has been optimized multiple times. The FS-12 system is currently operating under pumping configuration 2010 Scenario 01, which consists of the operation of four extraction wells (90EW0019, 90EW0025, 90EW0026, and 90EW0031) at a combined flow rate of 360 gpm (Figure I-1). The extracted water is conveyed to the FS-12 treatment building, where it is treated by a granular activated carbon system, and returned to the aquifer via 12 reinjection wells (AFCEE 2011b). Groundwater transport modeling using the 2004 FS-12 EDB plume shell and pumping configuration 2006 Scenario 01 (total system flow rate of 720 gpm) predicted that EDB at concentrations above the MMCL would be present at FS-12 through approximately 2048 (AFCEE 2010).

I1.2 STEP 1: CLEAN WATER LENS

As established in Section 4.1.1 and depicted graphically in Figure 4-1 of the main document, the first step in evaluating the possibility of VI for a groundwater plume is determining whether a continuous 3-ft-thick clean water lens is present above the entire plume and is expected to remain for the foreseeable future as long as the plume exists. If the evaluation indicates that a

clean water lens is present using the criteria presented in Section 4.1.1 of the main document, it can be concluded that the VI pathway is incomplete and no further evaluation is required.

The clean water lens evaluation at FS-12 included a review of available analytical data for the two FS-12 COCs, EDB and benzene. In the source area, other plume-related VOC data were also reviewed (i.e., BTEX compounds), as included in the list of VI COPCs in Table 4-1 of the main document. For this FS-12 VI evaluation, the absence of plume-related VOC detections in groundwater at the water table below the source area defines the presence of a clean water lens. For the FS-12 plume, however, the presence of a clean water lens is defined using the available EDB analytical data.

The following subsections evaluate the clean water lens at the two FS-12 areas of concern; the detached FS-12 plume located off-base; and the shallow groundwater associated with the on-base source area that contains residual concentrations of BTEX compounds.

I1.2.1 FS-12 Groundwater Plume

The locations of all the monitoring points used for the FS-12 VI evaluation are shown on Figure I-2, and the EDB data used to support this evaluation, and to illustrate the location of the EDB plume in the aquifer, are shown on the northwest-southeast and west-east cross-sectional depictions of the plume on Figures I-3 and I-4. The supporting analytical data are summarized in Table I-1. Well construction and sampling location information is included in Table I-2.

As described in the conceptual site model (CSM) in Section I1.1, the most recent monitoring data indicate that the FS-12 EDB plume is located deep in the aquifer (deeper than -30 ft msl). Characterization data collected under the SPEIM program confirm that the FS-12 plume is overlain by a substantial thickness of clean water well in excess of 3 ft. The data that support this aspect of the CSM are as follows:

- Groundwater vertical profile data collected between 2008 and 2010 at sample elevations above the FS-12 plume at 90MW0203A, 90MW0201A, and 90MW0200A, indicate the presence of at least a 70 ft thickness of clean water above the FS-12 plume.

- Monitoring data from 90MP0060C, D, E, and F in 2008 and 2010 indicate the presence of a clean water lens at the western boundary of the plume near Snake Pond and extraction well 90EW0031. It is noted that the 90MP0060 multiport well is no longer located within the plume footprint, but was historically and these data from 2008 and 2010 support the presence of clean water above the plume.
- Data collected at monitoring wells 90MW0016, 90MW0025, 90MW0076, and 90MW0053 in 2010 and 2011 further support the presence of a clean water lens above the FS-12 plume. In addition, vertical profile data collected in 2003 at 90MW0107A indicate the presence of at least a 110 ft thickness of clean water above the plume in the south.
- Groundwater vertical profile data were collected at the western arm area of FS-12 to characterize the plume in the area between 90EW0031 and 90EW0019. EDB data obtained at sample elevations above the plume at 90DP1008 in 2011 and 90DP0004A, 90DP0009, and 90DP0011 (Figure I-2) in 2004 indicate the presence of at least a 65 ft thickness of clean water above the plume at that time. Wells 90DP0004A and 90DP0011 are now located outside of the FS-12 plume boundary to the west; however, when completed in 2004, the western arm of the FS-12 plume was present in this area. In addition, data collected at monitoring well 90MW0048 in 2011 further support the presence of a clean water lens above the FS-12 plume in this area.

In summary, characterization and monitoring data from multiple locations throughout the area of the FS-12 plume confirm the presence of a clean water lens overlying the entire FS-12 plume well in excess of the 3 ft thickness criterion used for this VI screening evaluation. It is acknowledged, however, that some of these characterization data are not recent (i.e., dating back to 2003 in some cases). But when combined with more recent data collected in 2008 through 2011 and the overall understanding of the hydrogeologic aspect of the CSM, they still provide sound lines of evidence that the FS-12 plume is located deep in the aquifer and is overlain by a substantial thickness of clean water. Furthermore, given the substantial thickness of clean water above the entire plume and the ongoing remedial actions, a change in the clean water lens presence is not anticipated in the future.

I1.2.2 Source Area Groundwater

Long-term monitoring data, including data from 2010, for wells in the source area indicate that detectable concentrations of BTEX compounds remain in groundwater at the water table (Figure I-2 and Table I-1). Therefore, a clean water lens does not exist below the FS-12 source area and a complete VI pathway cannot be ruled out. Further VI evaluation (i.e., Step 2 of the VI evaluation process) is warranted for the FS-12 source area.

I1.3 STEP 2: BUILDINGS AND PREFERENTIAL AIRFLOW PATHWAYS

If it is determined that a constant 3-ft-thick lens of clean water does not exist or its presence cannot be demonstrated with an adequate level of certainty, the next step in a VI assessment is the evaluation of the proximity of potential receptors (Section 4.1.2 of main document). This is only necessary for the source area groundwater at FS-12.

I1.3.1 Source Area

The extent of BTEX detections in monitoring wells screened at or near the water table is shown on Figure I-5. As illustrated on this figure, the detections are limited to wells that are located on-base. The land above the FS-12 source area is undeveloped and there are no buildings or structures located within 100 feet of the monitoring wells where residual detections of BTEX compounds in groundwater remain (Figure I-5). However, underground utilities (water, telecommunications, and an abandoned fuel pipeline) are present along Greenway Road. The underground fuel pipeline that was the source of the FS-12 contamination was decommissioned and abandoned in place in 1997 (Woodard & Curran 1997). Decommissioning and abandonment consisted of removing residual fuels and then dividing the pipeline into segments and plugging the ends of each segment with approximately four feet of grout to prevent the pipeline acting as a potential conduit for contaminant migration in the future. In the particular area of interest, where residual BTEX detections are present in groundwater at the water table, the fuel pipeline below Greenway Road was divided into four segments ranging in length from 160 ft to 305 ft (Woodard & Curran 1997). The abandoned fuel pipeline and current utilities are not expected to be significant conduits for the potential migration of vapors since they do not lead to any existing structure or buildings in the immediate area shown on Figure I-5. Note that the former storage sheds shown to the north of 90WT0006 are no longer present.

Since the FS-12 source area is located on the MMR, future development, including the construction of new buildings in this area, is controlled through institutional controls specified under the Land Use Control program which is part of the selected remedy for FS-12 (AFCEE 2006). Specifically, the Air National Guard has administrative processes and procedures that require approval for all projects involving construction or digging/subsurface soil disturbance at

the MMR. In the event construction activities were planned in the FS-12 source area, the Installation Restoration Program would take appropriate measures to address VI concerns as they relate to any future structures and/or underground utilities or other potential preferential airflow pathways.

I2.0 CONCLUSIONS AND RECOMMENDATIONS

I2.1 CONCLUSIONS

A review of groundwater characterization and monitoring data collected at FS-12 indicates that a continuous clean water lens at least 3 ft thick is present above the entire body of the FS-12 plume and is expected to be present in the future as long as the plume exists. Due to the presence of a substantial clean water lens overlying the entire extent of the FS-12 plume, and the ongoing active treatment to control its migration, the VI pathway is considered incomplete in this area. However, residual BTEX concentrations are present at the water table below the FS-12 source area (located on-base). No buildings or structures are located in this area and future site development is controlled by on-base entities. Underground utilities do exist in this area but are not considered viable conduits for vapor migration. Therefore, the VI exposure pathway at the FS-12 source area is considered incomplete due to the absence of nearby receptors.

I2.2 RECOMMENDATIONS

No further monitoring or data collection is needed specific to VI. However, as part of the ongoing remedial actions at FS-12, AFCEE will continue to monitor the nature and extent of the FS-12 plume under the SPEIM program and the residual BTEX concentrations at the source area will be further evaluated during site closure activities. The VI exposure pathway will be re-evaluated if conditions change such that VI could become a concern.

I3.0 REFERENCES

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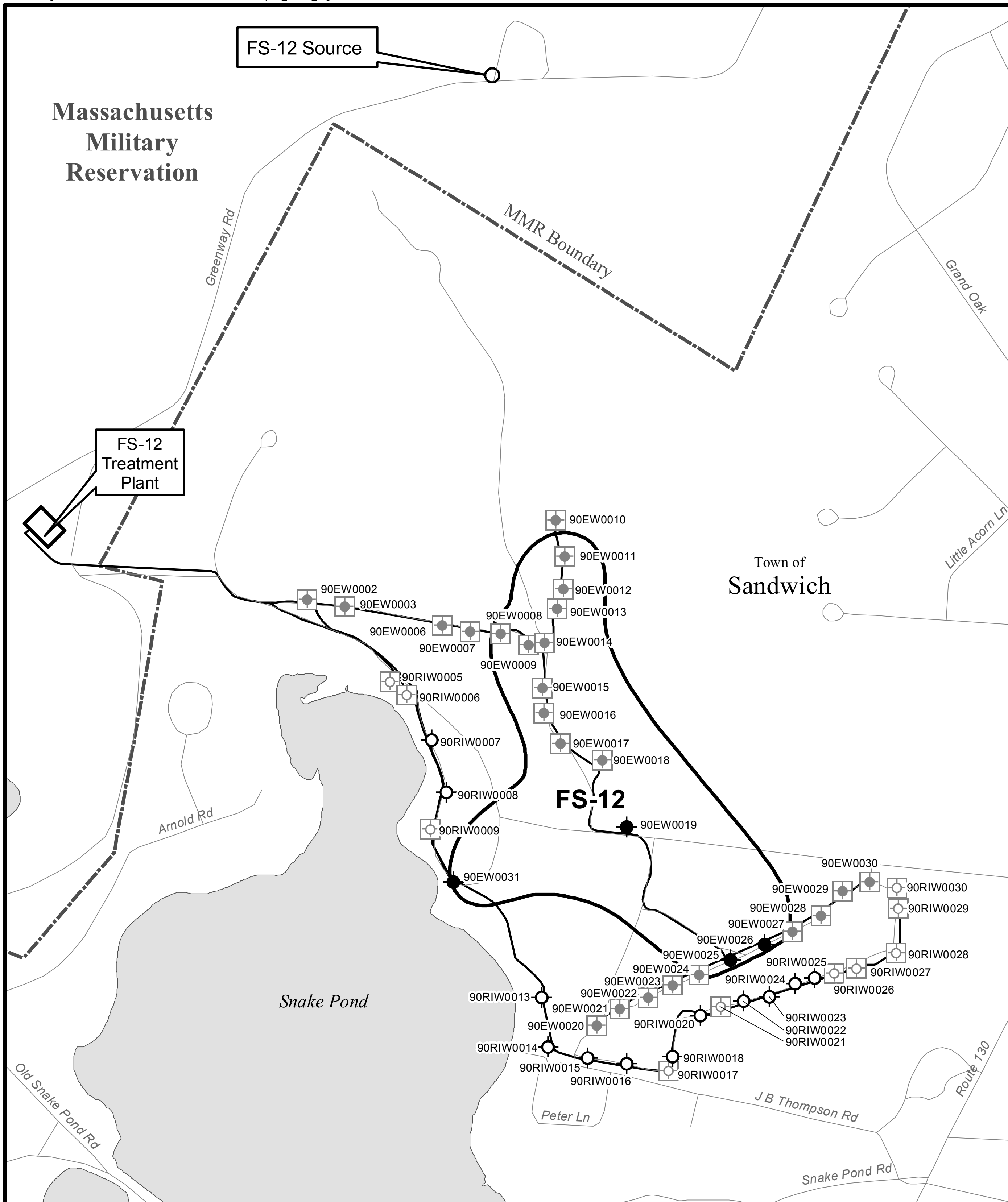

Legend

Data Source: AFCEE, February 2012, MMR-AFCEE Data Warehouse
MMR Boundary from Massachusetts Air National Guard 2011

- Extraction Well (On)
- Extraction Well (Off)
- Reinjection Well (On)
- Reinjection Well (Off)
- Plume Boundary
- MMR Boundary
- Treatment Pipeline
- Treatment Plant

N

0 320 640 Feet

NOTE: Well configuration represents 2010 Scenario 01 Pumping Configuration.

FIGURE I-1

FS-12 GROUNDWATER PLUME AND REMEDIAL SYSTEM

AFCEE - Massachusetts Military Reservation

Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

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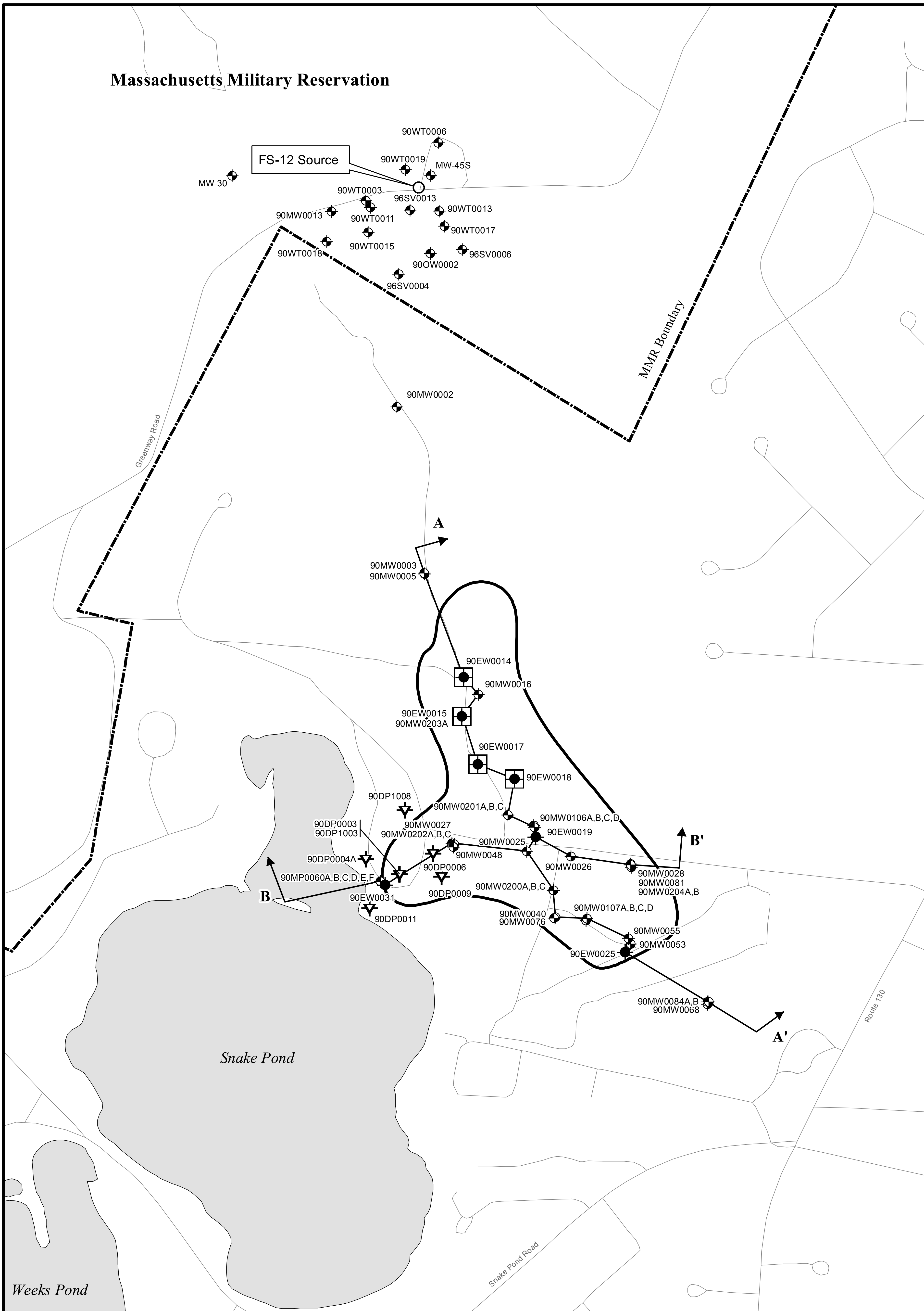

Data Source: AFCEE, February 2012, MMR-AFCEE Data Warehouse
MMR Boundary from Massachusetts Air National Guard 2011

Legend

- Monitoring Well
- Extraction Well
- Extraction Well (Off)
- Direct Push
- Plume Boundary (Based on 2010 Data)
- Massachusetts Military Reservation Boundary

N

0 270 540
Feet

FIGURE I-2

FS-12 GROUNDWATER PLUME AND LOCATION OF CROSS-SECTION LINES

AFCEE - Massachusetts Military Reservation

Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

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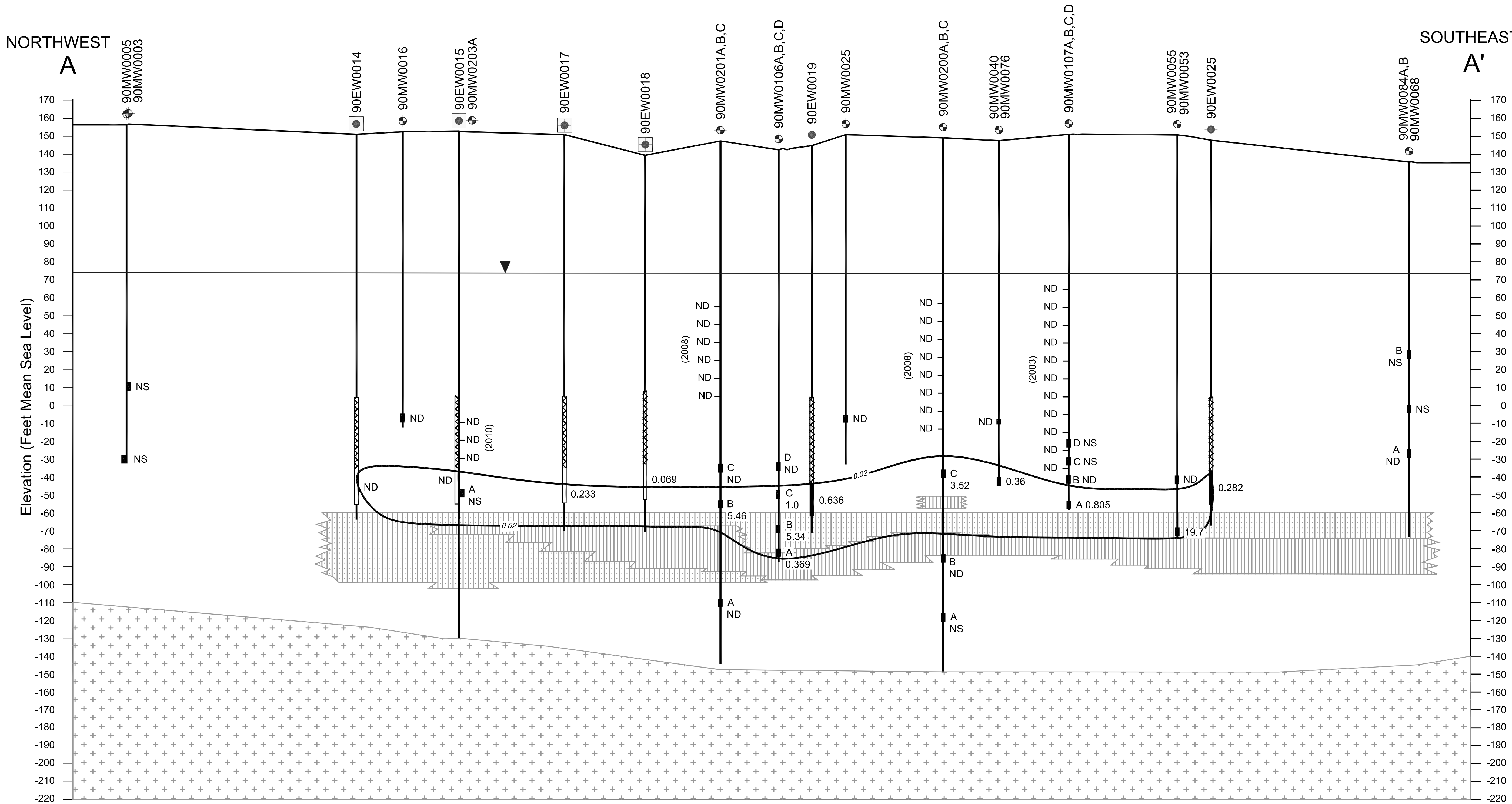


Legend

	Monitoring Well
	Extraction Well (On)
	Extraction Well (Off)
	Water Table
ND	Nondetect
NS	Not Sampled
BRL	EDB Data (µg/L) Collected in 2011 Unless Otherwise Noted
A	Well Screen ID
0.02	EDB Isoconcentration Contour (MMCL = 0.02 µg/L) (Dashed Where Inferred)
(2010) 1.2	EDB Vertical Profile Data (µg/L) (Date Collected)
	Extraction Well Packer
	Bedrock
	Silt
	Silty Sand

Data Source: AFCEE, February 2012, MMR-AFCEE Data Warehouse.

0 Feet V: 58 H: 267

FIGURE I-3

FS-12 CROSS-SECTION A-A'

AFCEE - Massachusetts Military Reservation

Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

CH2MHILL.

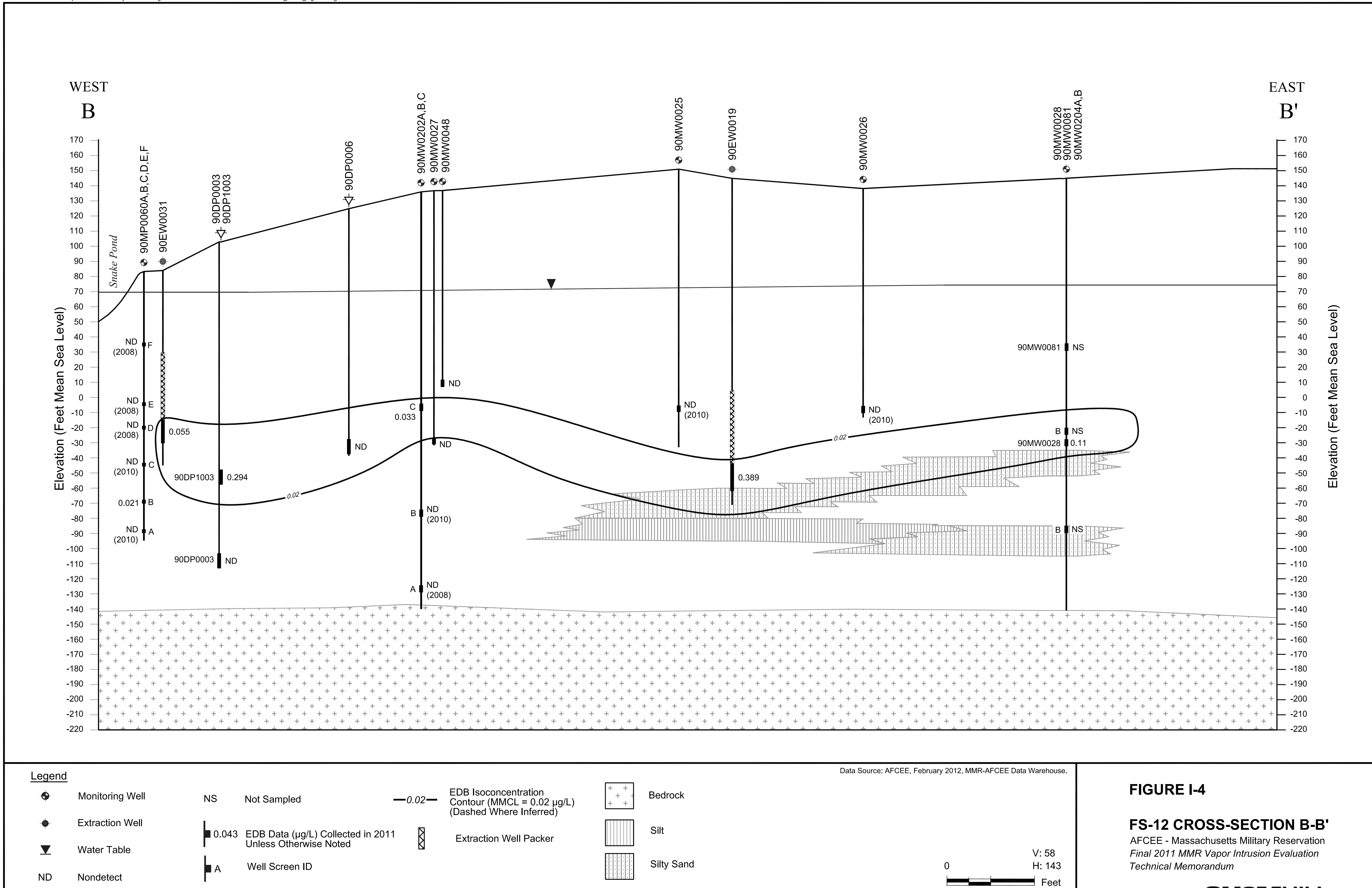


FIGURE I-4

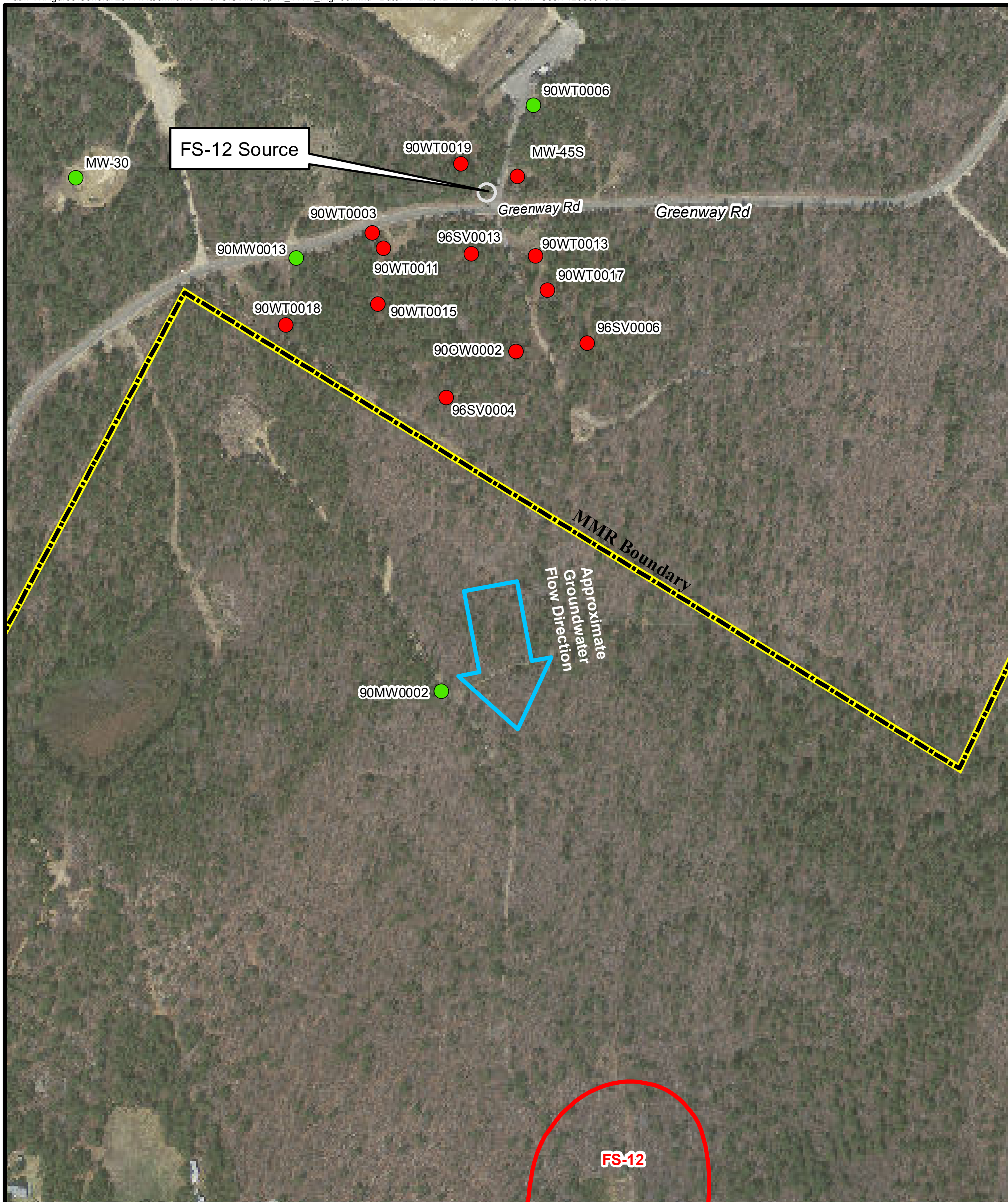
FS-12 CROSS-SECTION B-B'

AFCEE - Massachusetts Military Reservation

Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

CH2MHILL.

Path: Y:\Figures\General\2011\VItechmemo\Final\GIS\Arcmap\VI_11TM_FigI-05.mxd Date: 7/12/2012 Time: 11:34:05 AM User: 1268507872E



Legend

- Massachusetts Military Reservation Boundary
- Plume Boundary
- Monitoring Well - VI COPC Detected
- Monitoring Well - VI COPC Not Detected

Data Source: AFCEE, MMR-AFCEE Data Warehouse
MMR Boundary from Massachusetts Air National Guard 2011
2009 Aerial Photography from MassGIS

N

0 170 340 Feet

FIGURE I-5

FS-12 SOURCE AREA EXTENT OF WATER TABLE VI COPC DETECTIONS

AFCEE - Massachusetts Military Reservation

Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

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Table I-1
FS-12 Groundwater Data Used in Support of VI Evaluation
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Location	Date Sampled	Mid-Sample Elevation (ft msl)	Sampling Method[1]	VI COPC[2]	Result (µg/L)
FS-12 Groundwater Plume					
90DP0004A	5/13/2004	-5.0	VP	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
90DP0004A	5/13/2004	5.0	VP	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
90DP0004A	5/13/2004	15.0	VP	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
90DP0004A	5/13/2004	25.0	VP	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
90DP0004A	5/13/2004	35.0	VP	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
90DP0004A	5/13/2004	45.0	VP	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
90DP0004A	5/13/2004	55.0	VP	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
90DP0004A	5/13/2004	62.2	VP	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
90DP0009	5/11/2004	-8.0	VP	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
90DP0009	5/11/2004	2.0	VP	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
90DP0009	5/11/2004	12.0	VP	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
90DP0009	5/11/2004	22.0	VP	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
90DP0009	5/11/2004	32.0	VP	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
90DP0009	5/10/2004	42.0	VP	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
90DP0009	5/10/2004	52.0	VP	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
90DP0009	5/10/2004	62.0	VP	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
90DP0011	5/14/2004	6.0	VP	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
90DP0011	5/14/2004	16.0	VP	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
90DP0011	5/13/2004	26.0	VP	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
90DP0011	5/13/2004	36.0	VP	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
90DP0011	5/13/2004	46.0	VP	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
90DP0011	5/13/2004	56.0	VP	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
90DP1008	11/22/2011	-9.9	VP	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
90DP1008	11/22/2011	0.1	VP	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
90DP1008	11/22/2011	10.1	VP	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
90DP1008	11/28/2011	-19.9	VP	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
90DP1008	11/28/2011	-29.9	VP	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
90MP0060C	12/21/2010	-44.5	MW	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
90MP0060D	4/8/2008	-20.0	MW	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
90MP0060E	4/8/2008	-4.5	MW	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
90MP0060F	4/8/2008	35.0	MW	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
90MW0016	5/27/2010	-7.1	MW	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
90MW0025	5/27/2010	-7.5	MW	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
90MW0048	10/11/2011	9.3	MW	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
90MW0053	9/15/2011	191.7	MW	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
90MW0076	9/13/2011	-9.2	MW	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
90MW0107A	5/19/2003	-25.3	VP	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
90MW0107A	5/19/2003	-15.3	VP	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
90MW0107A	5/19/2003	-5.3	VP	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
90MW0107A	5/19/2003	4.7	VP	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
90MW0107A	5/19/2003	14.7	VP	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
90MW0107A	5/19/2003	24.7	VP	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
90MW0107A	5/19/2003	34.7	VP	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
90MW0107A	5/19/2003	44.7	VP	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
90MW0107A	5/19/2003	54.7	VP	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
90MW0107A	5/19/2003	64.7	VP	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
90MW0107A	5/20/2003	-35.3	VP	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
90MW0200A	1/23/2008	46.7	VP	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
90MW0200A	1/23/2008	56.7	VP	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
90MW0200A	1/24/2008	26.7	VP	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
90MW0200A	1/24/2008	36.7	VP	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
90MW0200A	1/25/2008	-13.3	VP	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND

Table I-1
FS-12 Groundwater Data Used in Support of VI Evaluation
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Location	Date Sampled	Mid-Sample Elevation (ft msl)	Sampling Method[1]	VI COPC[2]	Result (µg/L)
90MW0200A	1/25/2008	-3.3	VP	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
90MW0200A	1/25/2008	6.7	VP	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
90MW0200A	1/25/2008	16.7	VP	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
90MW0201A	2/25/2008	5.0	VP	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
90MW0201A	2/25/2008	15.0	VP	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
90MW0201A	2/25/2008	25.0	VP	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
90MW0201A	2/25/2008	35.0	VP	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
90MW0201A	2/22/2008	45.0	VP	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
90MW0201A	2/22/2008	55.0	VP	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
90MW0203A	3/18/2010	-9.5	VP	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
90MW0203A	3/19/2010	-19.5	VP	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
90MW0203A	3/19/2010	-29.5	VP	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
FS-12 Source Area Groundwater					
90MW0002	5/9/2008	66.4	MW	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
90MW0002	5/9/2008	66.4	MW	BENZENE	ND
90MW0002	5/9/2008	66.4	MW	ETHYLBENZENE	ND
90MW0002	5/9/2008	66.4	MW	M,P-XYLENE (SUM OF ISOMERS)	ND
90MW0002	5/9/2008	66.4	MW	O-XYLENE (1,2-DIMETHYLBENZENE)	ND
90MW0002	5/9/2008	66.4	MW	TOLUENE	ND
90MW0013	10/1/2001	66.9	MW	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
90MW0013	10/1/2001	66.9	MW	BENZENE	ND
90MW0013	10/1/2001	66.9	MW	ETHYLBENZENE	ND
90MW0013	10/1/2001	66.9	MW	TOLUENE	ND
90MW0013	10/1/2001	66.9	MW	XYLENES, TOTAL	ND
90WT0003	10/2/2001	66.6	MW	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
90WT0003	10/2/2001	66.6	MW	BENZENE	ND
90WT0003	10/2/2001	66.6	MW	ETHYLBENZENE	ND
90WT0003	10/2/2001	66.6	MW	TOLUENE	1.4
90WT0003	10/2/2001	66.6	MW	XYLENES, TOTAL	BRL
90WT0006	10/4/2001	64.8	MW	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
90WT0006	10/4/2001	64.8	MW	BENZENE	ND
90WT0006	10/4/2001	64.8	MW	ETHYLBENZENE	ND
90WT0006	10/4/2001	64.8	MW	TOLUENE	ND
90WT0006	10/4/2001	64.8	MW	XYLENES, TOTAL	ND
90WT0011	10/1/2001	66.0	MW	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
90WT0011	10/1/2001	66.0	MW	BENZENE	ND
90WT0011	10/1/2001	66.0	MW	ETHYLBENZENE	21
90WT0011	10/1/2001	66.0	MW	TOLUENE	ND
90WT0011	10/1/2001	66.0	MW	XYLENES, TOTAL	39
90WT0013	10/2/2001	66.1	MW	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
90WT0013	10/2/2001	66.1	MW	BENZENE	ND
90WT0013	10/2/2001	66.1	MW	ETHYLBENZENE	5.3
90WT0013	10/2/2001	66.1	MW	TOLUENE	14
90WT0013	10/2/2001	66.1	MW	XYLENES, TOTAL	110
90WT0015	10/1/2001	66.0	MW	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
90WT0015	10/1/2001	66.0	MW	BENZENE	ND
90WT0015	10/1/2001	66.0	MW	ETHYLBENZENE	30
90WT0015	10/1/2001	66.0	MW	TOLUENE	ND
90WT0015	10/1/2001	66.0	MW	XYLENES, TOTAL	15
90WT0017	10/2/2001	81.5	MW	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
90WT0017	10/2/2001	81.5	MW	BENZENE	ND
90WT0017	10/2/2001	81.5	MW	ETHYLBENZENE	61
90WT0017	10/2/2001	81.5	MW	TOLUENE	41
90WT0017	10/2/2001	81.5	MW	XYLENES, TOTAL	200

Table I-1
FS-12 Groundwater Data Used in Support of VI Evaluation
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Location	Date Sampled	Mid-Sample Elevation (ft msl)	Sampling Method[1]	VI COPC[2]	Result (µg/L)
90WT0018	10/2/2001	67.1	MW	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
90WT0018	10/2/2001	67.1	MW	BENZENE	ND
90WT0018	10/2/2001	67.1	MW	ETHYLBENZENE	54
90WT0018	10/2/2001	67.1	MW	TOLUENE	6.7
90WT0018	10/2/2001	67.1	MW	XYLENES, TOTAL	180
90WT0019	10/2/2001	70.4	MW	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
90WT0019	10/1/2001	70.4	MW	BENZENE	ND
90WT0019	10/1/2001	70.4	MW	ETHYLBENZENE	64
90WT0019	10/1/2001	70.4	MW	TOLUENE	11
90WT0019	10/1/2001	70.4	MW	XYLENES, TOTAL	400
96SV0004	5/25/2010	74.2	MW	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
96SV0004	5/25/2010	74.2	MW	BENZENE	BRL
96SV0004	5/25/2010	74.2	MW	ETHYLBENZENE	129
96SV0004	5/25/2010	74.2	MW	M,P-XYLENE (SUM OF ISOMERS)	357
96SV0004	5/25/2010	74.2	MW	O-XYLENE (1,2-DIMETHYLBENZENE)	165
96SV0004	5/25/2010	74.2	MW	TOLUENE	34
96SV0006	5/25/2010	69.7	MW	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
96SV0006	5/25/2010	69.7	MW	BENZENE	ND
96SV0006	5/25/2010	69.7	MW	ETHYLBENZENE	84
96SV0006	5/25/2010	69.7	MW	M,P-XYLENE (SUM OF ISOMERS)	219
96SV0006	5/25/2010	69.7	MW	O-XYLENE (1,2-DIMETHYLBENZENE)	102
96SV0006	5/25/2010	69.7	MW	TOLUENE	8.8
96SV0013	5/25/2010	71.9	MW	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
96SV0013	5/25/2010	71.9	MW	BENZENE	ND
96SV0013	5/25/2010	71.9	MW	ETHYLBENZENE	63
96SV0013	5/25/2010	71.9	MW	M,P-XYLENE (SUM OF ISOMERS)	201
96SV0013	5/25/2010	71.9	MW	O-XYLENE (1,2-DIMETHYLBENZENE)	98
96SV0013	5/25/2010	71.9	MW	TOLUENE	25
MW-30	9/15/1999	69.0	MW	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
MW-30	9/15/1999	69.0	MW	BENZENE	ND
MW-30	9/15/1999	69.0	MW	ETHYLBENZENE	ND
MW-30	9/15/1999	69.0	MW	TOLUENE	ND
MW-30	9/15/1999	69.0	MW	XYLENES, TOTAL	ND
MW-45S	10/11/2001	70.0	MW	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	ND
MW-45S	10/11/2001	70.0	MW	BENZENE	ND
MW-45S	10/11/2001	70.0	MW	ETHYLBENZENE	68
MW-45S	10/11/2001	70.0	MW	TOLUENE	480
MW-45S	10/11/2001	70.0	MW	XYLENES, TOTAL	490

Data Source: AFCEE, February 2012, MMR-AFCEE Data Warehouse

Notes:

1. Sample collection method:
   VP = vertical profile groundwater sampling (direct push, rotosonic, or screened hollow-stem auger drilling methods)
   MW = fixed monitoring well

2. See Table 4-1 of the main document for a complete list of VI COPCs.

The data summarized in this table specifically support the FS-12 clean water lens VI evaluation and typically include the most recent sampling results for each location for the plume-related VI COPCs only. If additional historic sampling data exist, they are available for review in the AFCEE-MMR Data Warehouse.

Vertical profile data presented only include the relevant sample intervals used to support this FS-12 VI evaluation; if analytical data from deeper sample intervals exist, they are available in the AFCEE MMR Data Warehouse.

Key:

BRL = below reporting limit
COPC = contaminant of potential concern
ft msl = feet mean sea level
FS-12 = Fuel Spill-12
ND = not detected
VI = vapor intrusion
µg/L = micrograms per liter

Table I-2
FS-12 Well Construction and Sample Location Information
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Location	Northing (ft)	Easting (ft)	Surface Elevation (ft msl)	Measuring Point Elevation (ft msl)	Total Well Depth (ft bgs)	Top Screen Depth (ft bgs)	Bottom Screen Depth (ft bgs)	Top Screen Elevation (ft msl)	Bottom Screen Elevation (ft msl)	Screen Length (ft)
90DP0004A	251284	868023	79	NA	NA	NA	NA	NA	NA	NA
90DP0009	251190	868423	122	121.41	160	150	160	-28.48	-38.48	10
90DP0011	251023	868043	71	NA	NA	NA	NA	NA	NA	NA
90DP1008	251543	868230	113	NA	NA	NA	NA	NA	NA	NA
90MP0060C	251175	868100	83	83.19	129	126.25	128.75	-43.25	-45.75	3
90MP0060D	251175	868100	83	83.12	105	102.02	104.52	-18.75	-21.25	3
90MP0060E	251175	868100	83	83.13	89	86.52	89.02	-3.25	-5.75	3
90MP0060F	251175	868100	83	83.09	50	47.02	49.52	36.25	33.75	3
90MW0016	252165	868620	153	155.39	162	157.25	162.25	-4.61	-9.61	5
90MW0025	251335	868877	151	150.58	161	156.32	160.62	-5.32	-9.62	4
90MW0048	251371	868493	137	136.41	130	125.09	129.95	11.75	6.89	5
90MW0053	250841	869431	150	149.75	194	189.22	194.12	-39.19	-44.09	5
90MW0076	250980	869021	148	147.43	159	155.50	158.50	-7.67	-10.67	3
90MW0107A	250966	869192	151	150.89	210	204.48	209.31	-53.28	-58.11	5
90MW0200A	251127	869019	149	148.95	271	265.17	270.00	-115.93	-120.76	5
90MW0201A	251526	868777	147	147.04	261	255.38	260.00	-107.91	-112.53	5
90MW0203A	252050	868532	153	152.50	205	199.70	204.34	-46.70	-51.34	5
96SV0004	254398	868197	159	158.20	100	69.50	99.50	89.20	59.20	30
96SV0006	254528	868534	160	159.40	105	75.20	105.20	84.70	54.70	30
96SV0013	254740	868258	162	157.90	105	75.00	105.00	86.90	56.90	30
90MW0002	253695	868186	157	159.57	96	86.00	96.00	71.40	61.40	10
90MW0013	254731	867839	147	150.38	86	75.50	85.50	71.90	61.90	10
90OW0002	254508	868365	158	160.00	105	61.07	102.44	96.93	55.56	41
90WT0003	254790	868021	159	161.34	98	87.50	97.50	71.60	61.60	10
90WT0006	255096	868406	165	167.57	105	95.00	105.00	69.80	59.80	10
90WT0011	254754	868047	161	160.56	100	90.00	100.30	71.10	60.80	10
90WT0013	254735	868411	163	166.17	102	92.00	102.00	71.10	61.10	10
90WT0015	254621	868034	160	159.64	99	89.00	99.00	71.00	61.00	10
90WT0017	254654	868440	163	165.00	104	60.82	102.23	102.18	60.77	41
90WT0018	254571	867814	158	160.00	104	80.59	101.31	77.41	56.69	21
90WT0019	254955	868232	163	165.71	103	82.25	102.97	80.75	60.03	21
MW-30	254922	867313	100	99.64	36	26.00	36.00	73.97	63.97	10
MW-45S	254925	868367	164	163.40	99	89.00	99.00	75.04	65.04	10

Data Source: AFCEE, January 2012, MMR-AFCEE Data Warehouse

Key:

bgs = below ground surface

FS-12 = Fuel Spill-12

ft = feet

msl = mean sea level

NA = data not available; locations are direct push vertical profile locations and have no permanent screens installed.

APPENDIX J

FS-13 Vapor Intrusion Evaluation

TABLE OF CONTENTS

Figure

Tables

ACRONYMS AND ABBREVIATIONS

AFCEE	Air Force Center for Engineering and the Environment
BRL	below reporting limit
COC	contaminant of concern
COPC	contaminant of potential concern
CS-10	Chemical Spill-10
EPA	U.S. Environmental Protection Agency
ESD	Explanation of Significant Differences
FS-13	Fuel Spill-13
ft	feet/foot
LTM	long term monitoring
MMR	Massachusetts Military Reservation
msl	mean sea level
SITM	Site Inspection Technical Memorandum
SSI	Supplemental Site Inspection
TCE	trichloroethene
VI	vapor intrusion
µg/L	micrograms per liter
1,2,4-TMB	1,2,4-trimethylbenzene
1,3,5-TMB	1,3,5-trimethylbenzene

J1.0 FUEL SPILL-13 VAPOR INTRUSION EVALUATION

J1.1 CONCEPTUAL SITE MODEL

The Fuel Spill-13 (FS-13) groundwater plume was a dilute dissolved-phase groundwater plume located within the boundary of the Massachusetts Military Reservation (MMR) in Sandwich, Massachusetts (Figure 1-2 of the main document). The FS-13 plume area (Figure J-1) is located within the footprint of Chemical Spill-10 (CS-10) plume, although it is shallower in the aquifer, with contamination near the water table. The groundwater contaminants of concern (COCs) for FS-13 are 1,2,4-trimethylbenzene (1,2,4-TMB) and 1,3,5-trimethylbenzene (1,3,5-TMB), or TMBs collectively. There are no applicable drinking water standards for 1,2,4-TMB and 1,3,5-TMB. However, the calculated hazard equivalent concentration, based on a hazard index equal to 1, for each COC is 17 micrograms per liter (μg/L) (AFCEE 2000). The FS-13 groundwater contamination has not been delineated as a contiguous plume since 2004 due to its limited extent. For reference, the 2004 FS-13 plume boundary is shown on Figure J-1.

The source of the FS-13 plume was a spill of an estimated 2,000 gallons of Jet Propulsion-4 jet fuel that is believed to have occurred in 1972 near the rotary at the east end of Connery Avenue. The fuel spill was discovered in 1972 during a routine walkover inspection of an underground fuel supply pipeline. Subsequently, the area was investigated and excavated and a section of pipe was replaced. A Site Inspection Technical Memorandum (SITM) was completed in 1996 and a Supplemental Site Inspection (SSI) was completed in 2006 for the FS-13 source area. No further action was recommended for the FS-13 source area based on the evaluation of sampling data collected from the site characterization efforts of the 1996 SITM and 2006 SSI. A decision document was prepared to document the no further action decision for the FS-13 source area (AFCEE 2008a, AFCEE 2012).

The topography of the land above the FS-13 plume area is characterized as a broad, flat, and gently southward sloping glacial outwash plain referred to as the Mashpee Pitted Plain. The 2004 FS-13 plume boundary was approximately 610 feet (ft) in length,

approximately 250 ft wide, and occupied approximately 3 acres. Within the footprint of the historic plume boundary the ground surface elevations is approximately 130 ft mean sea level (msl). The groundwater flow direction in the vicinity of FS-13 is generally to the south, and flow within the aquifer is primarily horizontal. The depth to groundwater in the vicinity of the FS-13 is approximately 65 ft below ground surface and the elevation of the water table is approximately 65 ft msl (AFCEE 2012).

A 2000 Record of Decision identified the remedy for the FS-13 plume as Limited Action, consisting of long term monitoring (LTM) and institutional controls (AFCEE 2000). The FS-13 LTM program included annual sampling of six monitoring wells in and downgradient of the FS-13 plume to document the natural attenuation of the COCs. Data collected over the course of the LTM program indicated that the COCs were not mobile and contamination had not migrated downgradient. The Air Force Center for Engineering and the Environment (AFCEE) submitted a request to the regulatory agencies in June 2005 to discontinue groundwater monitoring on the basis of a decreasing trend over a period of five years, the immobility of TMBs, and because human exposure to contaminated groundwater is restricted by institutional controls on the base. The U.S. Environmental Protection Agency (EPA) granted a conditional approval, which required preparation of an Explanation of Significant Difference (ESD), to document on-base institutional controls (EPA 2005). Based on this conditional approval, the FS-13 monitoring wells were abandoned in 2006.

In October 2007, the FS-13 source area was delisted as part of the partial deletion of sites from the Otis Air National Guard Base/Camp Edwards Superfund Site. A Final ESD was submitted in September 2008, which updated the Land Use Control language for FS-13 (AFCEE 2008b). A second ESD was submitted in September 2011, which updated the phrasing of the remedial action objectives for FS-13, added monitored natural attenuation as a component of the remedy, and updated the three-step process language which outlines the pathway to achieve site closure (AFCEE 2011).

Routine groundwater monitoring of FS-13 is no longer conducted. When last sampled in November 2004, the maximum concentrations of 1,2,4-TMB and 1,3,5-TMB in FS-13 groundwater were 383 µg/L and 143 µg/L, respectively, both in monitoring well 38MW0006 (AFCEE 2005). In April and May 2011, AFCEE installed two direct push vertical profile borings at FS-13 to re-evaluate current groundwater quality and assess remedial progress. The two direct push borings, 03DP1112 and 03DP1113, were completed near abandoned FS-13 wells 38MW0006 and 38MW0009, respectively (Figure J-1). These two locations, which are approximately 350 ft apart, were chosen because elevated 1,2,4-TMB and 1,3,5-TMB concentrations were historically detected in these monitoring wells and these two locations fall within the footprint of the 2004 FS-13 plume boundary. The data collected at these two locations indicated elevated concentrations of 1,2,4-TMB and 1,3,5-TMB remain above the calculated hazard equivalent concentration of 17 µg/L at the sampling interval approximately 10 ft below the water table. Although these recent TMB concentrations are similar to, or slightly lower than what was reported in 2004, clean up goals at FS-13 have not yet been reached. Direct push drilling will be used to complete vertical profiling near 03DP1112 and 03DP1113 in approximately five years in order to evaluate if 1,2,4-TMB and 1,3,5-TMB concentrations in groundwater have reached clean up levels and site closure can proceed (AFCEE 2012).

The subsections that follow present the results of the vapor intrusion (VI) screening evaluation using the most recent groundwater contaminant concentration data collected in 2011 from the two direct push borings discussed above.

J1.2 STEP 1: CLEAN WATER LENS

As established in Section 4.1.1 and depicted graphically in Figure 4-1 of the main document, the first step in evaluating the possibility of VI for a groundwater plume is determining whether a continuous 3-ft-thick clean water lens is present above the entire plume and is expected to remain for the foreseeable future as long as the plume exists. If the evaluation indicates that a clean water lens is present using the criteria presented in Section 4.1.1 of the main document, it can be concluded that the VI pathway is incomplete and no further evaluation is required.

The clean water lens evaluation for FS-13 included a review of available analytical data for the FS-13 COCs, 1,2,4-TMB and 1,3,5-TMB, as well as other site-related VI contaminants of potential concern (COPC) listed in Table 4-1 of the main document. For this FS-13 VI evaluation, the absence of 1,2,4-TMB and 1,3,5-TMB detections in groundwater at or near the water table defines the presence of a clean water lens.

The groundwater sampling locations used for the FS-13 VI evaluation are shown on Figure J-1. The most recent analytical data used to support this evaluation are summarized in Table J-1. The well construction and sampling location information used in this evaluation are included in Table J-2.

As shown in Table J-1, fuel-related 1,2,4-TMB was detected in a groundwater sample collected at the water table in direct push location 03DP1113. In addition, trichloroethene (TCE) was detected in a groundwater sample collected at the water table in direct push location 03DP1112. The source of the TCE is not known but is not believed to be related to FS-13; however, TCE is a VI COPC. Based on these detections, a clean water lens is not present in the FS-13 area, a complete VI pathway cannot be ruled out, and further VI evaluation (i.e., Step 2 of the groundwater VI evaluation process) is warranted.

J1.3 STEP 2: BUILDINGS AND PREFERENTIAL AIRFLOW PATHWAYS

There are no buildings within 100 ft of the 2004 FS-13 plume boundary. The nearest building is the MMR Information Center (Building 1805), which is located approximately 300 ft to the northwest of FS-13 on the southwest side of the rotary (Figure J-1).

Figure J-1 shows existing subsurface utilities in the vicinity of FS-13. One short section of storm water pipe (approximately 25 ft long) lies within the footprint of the 2004 plume boundary and several water, storm water, and wastewater pipes are located within 100 ft of the 2004 plume boundary to the north and southeast. Due to the proximity of the VI COPC detections at the water table to the preferential airflow pathways shown on

Figure J-1, and since the former plume boundary is within 100 ft of these utilities, further VI evaluation (i.e., Step 3 of the groundwater VI evaluation process) is needed.

J1.4 STEP 3: COMPARE GROUNDWATER CONCENTRATIONS TO VI SCREENING VALUES

Table J-3 compares the latest available VI COPC concentrations detected in groundwater (sampled in 2011) to the groundwater-to-indoor-air screening values presented in Table 4-1 of the main document. VI COPCs in groundwater samples collected at the water table at FS-13 include TCE at 03DP1112, which was detected at a concentration below the reporting limit (BRL) of 1 µg/L, and 1,2,4-TMB at 03DP1113, which was also detected at a BRL concentration. Both concentrations are below applicable groundwater-to-indoor-air screening values.

Part of the comparison to screening values in Step 3 includes evaluating whether VI COPC concentrations in groundwater are increasing, stable, or decreasing. Maximum TMB concentrations at 03DP1112, collected at the sampling interval below the water table, were consistent with 2004 concentrations (383 µg/L of 1,2,4-TMB, and 143 µg/L of 1,3,5-TMB) at adjacent abandoned monitoring well 38MW0006; however, concentrations to the south have decreased in the area of 03DP1113 and adjacent abandoned monitoring well 38MW0009 (264 µg/L of 1,2,4-TMB, and 119 µg/L of 1,3,5-TMB), indicating that concentrations in the FS-13 plume are attenuating (Table J-1 and AFCEE 2012).

Another component of Step 3 is to determine whether contaminant sources have been adequately controlled. The source area was addressed to the satisfaction of EPA, as described in Section J1.1. Furthermore, decreasing TMB concentrations in groundwater attest to the adequacy of controlling the residual sources at FS-13 (AFCEE 2012). Thus, available information indicates that contaminant sources in the vicinity of FS-13 have been adequately controlled.

The final component of Step 3 is to evaluate whether characterization data are adequate. The six abandoned monitoring wells provide a historical record of TMB concentrations from 2000 to 2004, and the two above-described direct push locations update the record with 2011 concentration data. In addition, the downgradient extent of water table contamination is bounded at abandoned well 38MW0007, which is screened at the water table; TMBs were not detected in groundwater samples from 38MW0007 in the two most recent sampling rounds in 2003 and 2004 (AFCEE 2012). Therefore, based on a review of current and historic data, the extent of residual contamination at FS-13 can be defined with reasonable confidence and characterization data are considered adequate for the purposes of assessing VI potential relative to the FS-13 plume area.

J2.0 CONCLUSIONS AND RECOMMENDATIONS

J2.1 CONCLUSIONS

A clean water lens is not present at FS-13. VI COPCs in groundwater have not been detected within 100 ft of any buildings; however, VI COPCs have been detected in groundwater within 100 ft of subsurface utilities. These findings necessitated the comparison of concentrations detected in groundwater samples collected at the water table to groundwater-to-indoor-air screening values. Detected VI COPC concentrations at the water table are below applicable screening values. In addition, TMB concentrations at FS-13 are stable or continue to attenuate, sources have been adequately controlled, and characterization data are adequate. Thus, the VI pathway is considered insignificant.

J2.2 RECOMMENDATIONS

No further monitoring or data collection is needed specific to VI. However, as part of the ongoing remedial actions at FS-13, AFCEE will assess the nature and extent of groundwater contaminants in the former FS-13 plume area and will re-evaluate the VI exposure pathway if conditions change such that VI could become a concern.

J3.0 REFERENCES

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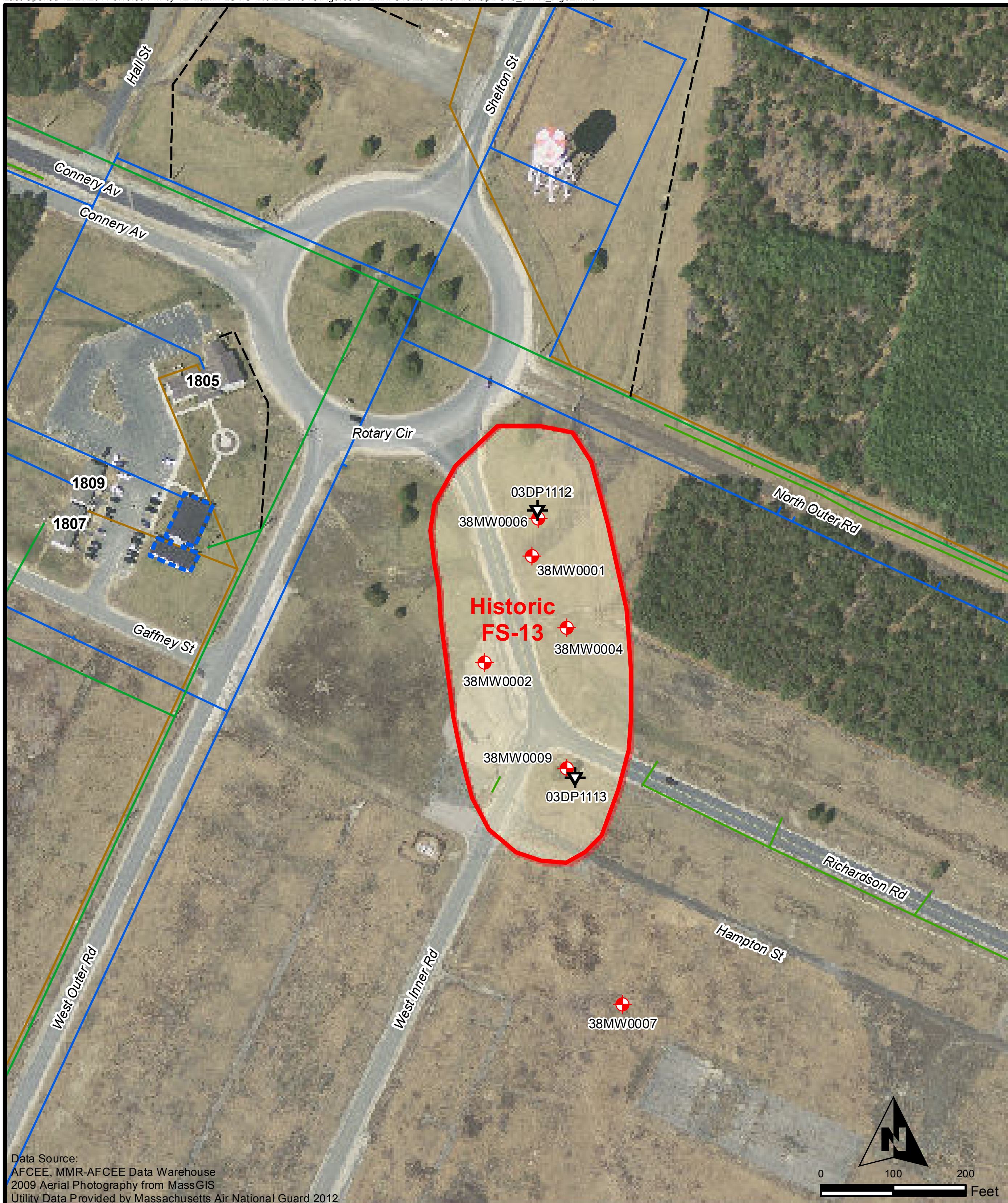

Legend

- Abandoned Monitoring Well
- Direct Push Location
- FS-13 2004 Plume Boundary
- Water Pipe
- Wastewater Pipe
- Storm Water Pipe
- Electrical Primary Line (Below Ground)
- Demolished Structure

FIGURE J-1

FS-13 HISTORIC PLUME BOUNDARY, MONITORING LOCATIONS AND AREA UTILITIES

AFCEE - Massachusetts Military Reservation

Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

CH2MHILL.

Table J-1
FS-13 Groundwater Data Used in Support of VI Evaluation
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Location	Date Sampled	Mid-Sample Elevation (ft msl)	Sampling Method[1]	1,2,4- TMB[2] (µg/L)	1,3,5-TMB[2] (µg/L)	TCE[2] (µg/L)
03DP1112	4/18/2011	62.5	VP	ND	ND	BRL
03DP1112	4/18/2011	52.5	VP	416	160	ND
03DP1112	4/18/2011	42.5	VP	ND	ND	ND
03DP1112	4/18/2011	32.5	VP	ND	ND	ND
03DP1112	4/18/2011	22.5	VP	ND	ND	ND
03DP1112	4/18/2011	12.5	VP	ND	ND	ND
03DP1112	4/19/2011	2.5	VP	ND	ND	ND
03DP1113	4/29/2011	60.5	VP	BRL	ND	ND
03DP1113	4/29/2011	50.5	VP	99	54	ND
03DP1113	5/2/2011	40.5	VP	ND	ND	ND
03DP1113	5/2/2011	30.5	VP	ND	ND	ND
03DP1113	5/2/2012	20.5	VP	ND	ND	ND
03DP1113	5/2/2012	10.5	VP	ND	ND	ND
03DP1113	5/2/2012	0.5	VP	ND	ND	ND

Data Source: AFCEE, June 2012, MMR-AFCEE Data Warehouse

Notes:
1. Sample collection methodology:
   VP = vertical profile groundwater sampling (direct push, rotosonic, or screened hollow-stem auger drilling methods)
2. See Table 4-1 of the main document for a complete list of VI COPCs.

The data summarized in this table specifically support the FS-13 clean water lens VI evaluation and typically include the most recent sampling results for each location. If additional historic sampling data exist, they are available for review in the AFCEE-MMR Data Warehouse.

Vertical profile data presented only include the relevant sample intervals used to support this FS-13 VI evaluation; if analytical data from deeper sample intervals exist, they are available in the AFCEE MMR Data Warehouse.

Key:
BRL = below reporting limit
COPC = contaminant of potential concern
FS-13 = Fuel Spill-13
ft msl = feet mean sea level
ND = not detected
TCE = trichloroethene
VI = vapor intrusion
µg/L = micrograms per liter
1,2,4 TMB = 1,2,4-trimethylbenzene
1,3,5 TMB = 1,3,5-trimethylbenzene

Table J-2
FS-13 Well Construction and Sample Location Information
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Location	Northing (ft)	Easting (ft)	Surface Elevation (ft msl)	Measuring Point Elevation (ft msl)	Total Well Depth (ft bgs)	Top Screen Depth (ft bgs)	Bottom Screen Depth (ft bgs)	Top Screen Elevation (ft msl)	Bottom Screen Elevation (ft msl)	Screen Length (ft)
03DP1112	243272	860368	129	NA	NA	NA	NA	NA	NA	NA
03DP1113	242901	860420	128	NA	NA	NA	NA	NA	NA	NA

Data Source: AFCEE, June 2012, MMR-AFCEE Data Warehouse

Key:
bgs = below ground surface
FS-13 = Fuel Spill-13
ft = feet
msl = mean sea level
NA = no applicable; locations are direct push vertical profile locations and have no permanent well screens installed.

Table J-3
Comparison of VI COPC Concentrations in FS-13 Groundwater to Applicable Groundwater-to-Indoor Air Screening Values
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Location	Date	Mid-screen elevation (ft msl)	Sampling Method[1]	VI COPC[2]	Result	DL	RL	MCP Method 1 GW-2 Standard[3] (µg/L)	VI Screening Value Exceeded?	Generic Unrestricted Groundwater Screening Value[4] (µg/L)	VI Screening Value Exceeded?
					All units = µg/L						
03DP1112	4/18/2011	62.5	VP	TRICHLOROETHENE (TCE)	BRL	0.20	1	30	No	5	No
03DP1113	4/29/2011	60.5	VP	1,2,4-TRIMETHYLBENZENE	BRL	0.22	1	NE	NA	7.8	No

Data Source: AFCEE, March 2012, MMR-AFCEE Data Warehouse

Notes:

1. Sampling method: VP = vertical profile.
2. All samples analyzed for VOCs by EPA Method 8260B.
3. 310 CMR 40.0974(2) http://www.mass.gov/dep/cleanup/laws/0974_2.htm.
4. EPA, 2002, Draft Guidance for Evaluating the VI to Indoor Air Pathway from Groundwater and Soils http://www.epa.gov/osw/hazard/correctiveaction/eis/vapor/complete.pdf, using target risk levels of 1×10^{-6} excess lifetime cancer risk and noncancer hazard quotient of 0.1 in accordance with best practices for vapor intrusion screening to account for cumulative effects from multiple chemicals. Values updated with May 2012 Regional Screening Levels (Residential Indoor Air) for Chemical Contaminants at Superfund Sites http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm.

Screening values shown (both the MassDEP MCP Method 1 Groundwater-2 screening values and generic unrestricted groundwater screening values) are summarized in Table 4-1 of the main document.

Key:

BRL = below reporting limit
DL = detection limit
EPA = United States Environmental Protection Agency
ft msl = feet mean sea level
GW-2 = MCP Method 1 GW-2 groundwater standard
MCP = Massachusetts Contingency Plan
MassDEP = Massachusetts Department of Environmental Protection
NA = not applicable
NE = not established
RL = reporting limit
VI COPC = Vapor Intrusion Contaminant of Potential Concern
VOC = volatile organic compound
µg/L = micrograms per liter

APPENDIX K

FS-28 Vapor Intrusion Evaluation

TABLE OF CONTENTS

Figures

Tables

ACRONYMS AND ABBREVIATIONS

AFCEE	Air Force Center for Engineering and the Environment
bgs	below ground surface
COC	contaminant of concern
EDB	ethylene dibromide
ETD	extraction, treatment, and discharge
FS-28	Fuel Spill-28
ft	foot/feet
gpm	gallons per minute
MMCL	Massachusetts Maximum Contaminant Level
MMR	Massachusetts Military Reservation
msl	mean sea level
RI	remedial investigation
SPEIM	System Performance and Ecological Impact Monitoring
SWOU	Southwest Operable Unit
SWP	shallow well point
VI	vapor intrusion
VOC	volatile organic compound
µg/L	micrograms per liter

K1.0 FUEL SPILL-28 VAPOR INTRUSION DATA EVALUATION

K1.1 FS-28 CONCEPTUAL SITE MODEL

The Fuel Spill–28 (FS-28) groundwater plume is a large dilute dissolved-phase groundwater plume located south of the Massachusetts Military Reservation (MMR) in Falmouth, Massachusetts (Figure 1-2 of main document), which is detached from its source area. The FS-28 plume (Figure K-1) is defined as the extent of groundwater contaminated with ethylene dibromide (EDB), the only FS-28 groundwater plume contaminant of concern (COC) (AFCEE 2000), at concentrations exceeding the Massachusetts Maximum Contaminant Level (MMCL) of 0.02 micrograms per liter (µg/L).

The FS-28 source area has not been identified. It is speculated that the plume originated from a release or releases of aviation gasoline at or near the ground surface on the MMR which resulted in the EDB (a constituent of aviation gasoline) reaching the groundwater.

The FS-28 plume is comprised of three distinct portions in a north-south orientation. A plan view of the FS-28 plume, along with the locations of lines of cross-section and sampling points used to support this vapor intrusion (VI) evaluation, are shown on Figure K-2. Cross-sectional views of the FS-28 plume that show the extent of EDB contamination are provided on Figures K-3 and K-4.

Based on the most recent groundwater monitoring data collected in 2010, the main (northernmost) body of the FS-28 plume is approximately 5,000 feet (ft) long, up to 1,500 ft wide, and up to 100 ft thick in the deeper portion of the aquifer. The trailing edge of the main body of the FS-28 plume is now located approximately 1.5 miles (8,000 ft) south of the southern MMR boundary In addition to the main body of the FS-28 plume, two detached lobes exist to the south of the main plume. The smaller of the two lobes, the detached shallow lobe, is located approximately 750 ft south of the main plume; this smaller lobe is approximately 450 long, up to 100 ft wide, and 10 to 20 ft thick where it is present in the shallower portion of the aquifer. Historically, this

lobe of the FS-28 EDB plume upwelled and discharged to the Coonamessett River and adjacent cranberry bogs at detectable concentrations in surface water (Figures K-2 and K-4). However, only sporadic and very low concentration detections of EDB have been observed in surface water since 2006 (AFCEE 2010 and 2011c) indicating that the discharge of the plume contaminants to the Coonamessett River and bog system is much diminished. Isolated low concentration detections of EDB in surface water are possible in the future as the remaining EDB concentrations in groundwater located below the river and bog system attenuate and discharge.

The larger of the two southern lobes, the southern deep lobe, is located farther to the south and deeper in the aquifer. It is approximately 3,750 ft long, up to 300 ft wide, and up to 75 ft thick. The southernmost portion of this plume lobe rises in the aquifer and flows towards Pond 14 (Figures K-2 and K-4).

The topography of the land above the FS-28 plume can be characterized as a broad, flat, and gently sloping glacial outwash plain. Within the footprint of the plume, the maximum and minimum ground surface elevations are 82 ft mean sea level (msl), and 18 ft msl, respectively.

The groundwater flow direction in the vicinity of the FS-28 plume in generally to the south. Flow within the aquifer is primarily horizontal with stronger vertical gradients near surface water bodies such as rivers and ponds that increase the potential for vertical flow. The depth to water in the vicinity of the FS-28 plume ranges from less than a few feet near the ponds, rivers, and cranberry bogs to approximately 80 ft below ground surface (bgs) in the upland areas; the elevation of the water table within the FS-28 area ranges from approximately 35 ft msl in the north to 20 ft msl in the south. The aquifer saturated thickness in the FS-28 area is approximately 200 to 250 ft. Most, if not all of the FS-28 groundwater plume is overlain by a clean water lens that is up to 120 ft thick.

The FS-28 extraction, treatment, and discharge (ETD) remedial system was designed to treat a maximum of 750 gallons per minute (gpm). The Air Force Center for Engineering and the Environment (AFCEE) installed the ETD system under time critical (1997) and

non-time critical (1999) actions which became the selected alternative in the FS-28 Record of Decision (AFCEE 2000). At the time of system startup on 14 October 1997, the ETD system consisted of one extraction well (69EW0001) with the goal of capturing and remediating the main body (northernmost portion) of the plume. On 06 April 1999, the remedial system was expanded with the startup of the shallow well point (SWP) system which consists of an array of 204 wellpoints (Figure K-1). The SWP system was installed to intercept shallow EDB-contaminated groundwater before it discharged to the Coonamessett River or associated cranberry bogs. During 2007, the FS-28 ETD system was further expanded through the installation of a second extraction well (69EW0002) to remediate the deeper leading edge lobe of the plume (Figure K-1). Extraction well 69EW0002 came on-line on 11 December 2007; performance monitoring data indicate that this leading edge lobe of the plume is being captured and cut off through the operation of 69EW0002. The portion of the deep lobe located hydraulically downgradient (i.e., south) of 69EW0002 is expected to naturally attenuate as it migrates south towards Pond 14 (Figure K-2) (AFCEE 2010).

On 07 November 2008, the SWP system was shut down for an interim period while data gap investigative activities were conducted (AFCEE 2009). The 2008/2009 data gap investigation and optimization evaluation concluded that although the SWP system had been successful in remediating the FS-28 plume in this area, it was no longer effective in remediating the remaining residual EDB contamination near the SWPs and consequently the system was permanently shut down on 25 February 2010 and dismantled in early 2011 (AFCEE 2011c).

At the time of the preparation of this document in December 2011, the FS-28 ETD system is operating at a total flow rate of 625 gpm, 550 gpm from 69EW0001, and 75 gpm from 69EW0002. The extracted water is conveyed to the FS-28 treatment plant where it is treated by a granular activated carbon system and discharged to the Coonamessett River via two vertical riser pipes (i.e., bubblers) (AFCEE 2011b). The FS-28 plume and treatment system are shown on Figure K-1.

Groundwater transport modeling conducted in 2004 predicted that EDB at concentrations above the MMCL would be present in the main body of the FS-28 plume (i.e., north of 69EW0001) through approximately 2047 (AFCEE 2004). It is noted that due to the complexity of the hydrogeology in the area of the deep leading edge lobe, the groundwater model will not be used to assess the fate and transport of this portion of the FS-28 plume. Rather, monitoring data collected under the System Performance and Ecological Impact Monitoring (SPEIM) program will be used to evaluate the cleanup of the aquifer in this area.

K1.2 STEP 1: CLEAN WATER LENS

As established in Section 4.0 and depicted graphically in Figure 4-1 of the main document, the first step in evaluating the possibility of VI for a groundwater plume is determining whether and where a 3-ft thick clean water lens is constantly present above the plume and is expected to remain for the foreseeable future as long as the plume exists. If the evaluation indicates that a clean water lens is present using the criteria presented in Section 4.1.1 of the main document, it can be concluded that the VI pathway is incomplete and no further evaluation is required.

Based on the outcome of a risk assessment using data collected in support of the *South West Operable Unit (SWOU) Remedial Investigation* (AFCEE 1999), the groundwater COC for the FS-28 plume is EDB. The site characterization data collected during the remedial investigation (RI) did not indicate the widespread presence of other MMR-related volatile organic compounds (VOCs) within the FS-28 plume. Therefore, for the purposes of this VI evaluation, the presence of clean water lens can be evaluated at FS-28 by assessing the EDB analytical data collected during and since the 1999 RI.

Characterization data, as detailed further below, indicate that a lens of clean groundwater between approximately 5 and 100 ft thick exists over the majority of the FS-28 plume. As noted in Section 2.0 of the main document, the presence of a clean water lens is characteristic of many of the MMR groundwater plumes. This lens of clean water accumulates above the plumes due to recharge accretion that causes the plumes to

descend in the aquifer as they migrate away from their source areas. However, the clean water lens at FS-28 is less thick in two areas of limited extent where the plume rises in the aquifer due to groundwater discharge to surface water bodies. Specifically, the EDB plume is known to rise in the aquifer in the vicinity of the former SWPs near the Coonamessett River and at the distal end of the southernmost lobe near Pond 14 (Figures K-2, K-3, and K-4).

The following subsections evaluate the clean water lens for the three FS-28 plume areas; the main body of the plume north of 69EW0001, the smaller shallow detached plume lobe near the former SWP system, and the southernmost deeper plume lobe. The locations of all the sampling points used for this VI evaluation are shown on Figures K-2 and K-5. The data used to support this VI evaluation are primarily shown on the cross-sectional depictions of the plume on Figures K-3 and K-4, and analytical EDB data relevant to assessing the presence of the clean water lens are presented in Table K-1. Finally, well construction and sampling location information used is included in Table K-2.

K1.2.1 FS-28 Main Plume Body

As shown in Figure K-3, the main body of the FS-28 plume is located relatively deep in the aquifer and is overlain by a clean water lens at least 40 ft thick. This characterization is based on groundwater data collected at monitoring wells and from groundwater vertical profile data collected at several locations throughout the main body of the plume.

Direct push vertical profile data were collected along the axis of the plume in the area north of 69EW0001 in 2004 as part of a remedial system optimization evaluation (AFCEE 2006). The vertical profile data collected from locations 69DP0105, 69DP0107, and 69DP0108 demonstrate that a clean water lens at least 80 ft thick is present above the main body of the plume in this area (Figure K-3 and Table K-1).

North of the western branch of Coonamessett Pond, vertical profile data collected in 1997 from locations 69MW1400 and 69MW1401 as part of the RI provide evidence of a clean

water lens at that time that is at least 40 ft thick. Although these characterization data are not recent, when combined with more recent data collected to the south in 2004 (described above) and the overall understanding of the hydrogeologic conceptual model in this area, they still provide a sound line of evidence that the main body of the FS-28 plume is located deep in the aquifer and is overlain by a clean water lens well in excess of the 3-ft thickness criteria used for this VI screening evaluation.

The main body of the FS-28 plume is currently being contained through the operation of extraction well 69EW0001 based on modeling evaluations and on monitoring data collected at the 69MW1303 and 69MW1317 well clusters (Figure K-3). Therefore, due to the evidence of a substantial clean water lens overlying this portion of the FS-28 plume and the ongoing active treatment to control its migration, further VI evaluation in this portion of the plume is not necessary since the VI pathway is incomplete.

K1.2.2 Detached Shallow Lobe in Vicinity of Former SWPs

The characterization of the portion of the FS-28 plume in the area of the former SWP system was updated in 2008/2009 as part of an optimization evaluation that resulted in the shutdown of the SWP system. The evaluation concluded that the operation of the SWP system has been successful in remediating this portion of the plume. The characterization data indicated that the extent of residual EDB contamination in this area is very limited and the remnants of the plume are expected to naturally attenuate with no further active treatment (AFCEE 2011a).

The estimated extent of residual EDB contamination in this area is depicted in cross-sectional view on Figure K-4 based on the data collected in 2008/2009. An element of the 2008/2009 characterization effort was completed using "pushpoint" samplers to determine the extent of the residual EDB concentrations in shallow groundwater (i.e., within 1 to 2 ft of the surface) below the area where the upwelling was most prominent in the past and where the SWP system was located (Figure K-5 and Table K-1).

As shown in Figures K-2 and K-4, the characterization data collected in this area suggest that this lobe of the FS-28 plume rises in the aquifer towards the river and bog system from depth within the aquifer. The upgradient (i.e., northern) portion of the lobe is interpreted to be present relatively deep in the aquifer (approximately -95 to -125 ft msl), based on the vertical profile data collected at 69DP0149. These data indicate that a clean water lens in excess of 100 ft thick is present in the vicinity of 69DP0149. The current interpretation of these characterization data assumes the EDB contamination identified at depth at 69DP0149 is connected to the EDB contamination detected shallower (approximately +10 to -15 ft msl) in the aquifer at 69DP0147 (Figure K-4 and Table K-1). Although EDB was detected shallower in the aquifer at 69DP0147 than at 69DP0149, the 2008 vertical profile data confirm that the plume remains overlain by approximately 9.5 ft of clean water immediately north of this former cranberry bog where the SWP system was installed. The pushpoint sampling completed in 2008/2009 identified an area below the northern stretch of the western bog ditch where EDB was detected at the water table prior to the discharge of the groundwater to surface water; these detections were sporadic in nature, limited in extent below the bog ditch, and at concentrations ranging from below the reporting limit to 0.128 μg/L (AFCEE 2009). The distribution of the EDB detections from the pushpoint sampling are illustrated on Figure K-5 and the analytical results are presented in Table K-1. It is also noted that no EDB was detected at monitoring well 69MW0033A (installed at the location of 69DP0147 and screened relatively shallow in the aquifer at 20 to 25 ft below water table) in February 2011 (Figure K-4 and Table K-1). Although EDB was detected at 69MW0033A during prior sampling events, the most recent data provide further evidence that EDB detections in this area are sporadic in nature.

As part of the 2008/2009 investigation, the western extent of this area of shallow contamination was determined by the sampling results at direct push vertical profile location 69DP0148 (Figure K-5). As shown in Table K-1, approximately 160 ft of groundwater with no EDB detections was encountered prior to reaching four consecutive intervals where EDB concentrations at or below the MMCL were reported. In addition, sampling at 69PZ1296A, located approximately 300 ft west of the bog ditch where the

pushpoint sampling was conducted, resulted in no detection of EDB. This well is screened between 2.5 and 7.5 ft below the water table and provides further evidence of the presence of a clean water lens at the water table interface in this area.

However, the most recent EDB sample results from location 69PZ1291A (sampling depth of 10 to 15 ft bgs and water table of approximately 3.5 ft bgs) located adjacent to the western bog ditch, indicate the presence of EDB at concentrations below the reporting limit of 0.01 μg/L (Table K-1).

Based on the data collected during the 2008/2009 pushpoint investigation and the sporadic detection of EDB in some of the shallow groundwater monitoring wells near the former SWP system, the presence of a clean water lens cannot be confirmed throughout this area at all times. However, characterization data do suggest that the residual amounts of EDB contamination in groundwater in this area are very limited in extent and are only present in the shallow portion of the aquifer either at or near the water table in close proximity to the northwestern portion of the bog ditch (between location 69MW0033A and 69PZ1291A on Figure K-5). As noted earlier, these residual concentrations of EDB in the aquifer below the former SWPs are expected to naturally attenuate over time.

In conclusion, based on a review of the available data, a clean water lens may not always be present over all of the shallow lobe. Therefore, an incomplete VI pathway cannot be ruled out based on the continual presence of a clean water lens and further VI evaluation (i.e., Step 2 of the VI evaluation process) is warranted in the area to the west of the bog where the SWP system was located.

K1.2.3 Southern Deep Lobe

Between 2004 and 2008, an investigation was conducted to characterize the southern deep lobe of the FS-28 plume that was south of the FS-28 ETD system (AFCEE 2010, 2007, 2006). As part of this investigation, vertical profile groundwater sampling was completed at 32 locations throughout this area. In addition, a pushpoint investigation was completed in 2007/2008 to determine whether the distal end of this plume lobe was

discharging to Pond 14 at detectable concentrations. In summary, the characterization data collected between 2004 and 2008 led to a thorough understanding of the nature and extent of this plume lobe including confirmation of the presence of a clean water lens above the southern deep lobe of the plume.

From north to south, groundwater vertical profile data from locations 69DP0104, 69DP0111, 69DP0118, 69DP0131, 69DP0136, and 69DP0141 indicate the presence of a minimum of 23 ft of clean water (at 69DP0104) and up to 100 ft of clean water (at 69DP0111) above the first EDB detections encountered (Figure K-4 and Table K-1).

South of Sandwich Road (and hydraulically downgradient), the vertical profile data collected at 69DP0141 provides evidence that the southern deep lobe is rising in the aquifer towards Pond 14, as shown in Figures K-2 and K-4; however, the plume remains overlain by at least 60 ft of clean water at this location. Further downgradient of this location, in Pond 14, the 2007/2008 pushpoint survey along the projected flow path of the southern deep lobe (locations 69DP3000 through 69DP3019) resulted in no detections of EDB (AFCEE 2009). This indicates that, although the FS-28 plume does rise in the aquifer due to the hydraulic influence of Pond 14, there is no evidence of plume discharge to Pond 14 and a diminished clean water lens at the distal end of the plume.

Based on the characterization data collected between 2004 and 2008, it can be concluded that the FS-28 plume's deep southern lobe is constantly overlain by a clean water lens in excess of three feet thick. Furthermore, the majority of this portion of the plume is being contained through the operation of extraction well 69EW0002. The EDB concentrations in the uncaptured portion of the deep leading edge lobe (south of 69EW0002) are expected to decline over time through the processes of natural attenuation. Therefore, the data indicate that the VI pathway is incomplete.

K1.3 STEP 2: BUILDINGS AND PREFERENTIAL AIRFLOW PATHWAYS

If it is determined that a constant 3-ft lens of clean water does not exist or its presence cannot be demonstrated with an adequate level of certainty, the next step in a VI

assessment is the evaluation of the proximity of potential receptors (Section 4.1.2 of main text). This is only necessary for the portion of the plume near the former SWPs.

K1.3.1 Detached Shallow Lobe in Vicinity of SWPs

Several residential buildings (houses and garden sheds) are present in the area to the west of the cranberry bog ditch where the detached shallow lobe of the FS-28 plume is known to discharge (Figure K-5). One of these structures is located within 100 ft of the bog ditch west of the former SWP system. As noted in Section K1.2.2, although a clean water lens of at least 3 ft in thickness exists in much of this area, there is evidence that EDB detections are present at the water table near the bog ditch. Therefore, the proximity of this building prompts further VI evaluation (i.e., Step 3 of the VI evaluation process) in the area to the west of the former SWP system.

K1.4 STEP 3: COMPARE GROUNDWATER CONCENTRATIONS TO VI SCREENING VALUES

If a constant three-foot thick clean water lens cannot be identified with reasonable certainty or is not present, and an occupied building or preferential airflow pathway is located within 100 ft of detections of any VI contaminant of potential concern, the third step in the VI assessment is the comparison of groundwater concentrations to the screening values specified in Table 4-1 of the main document. Section 4.1.3 of main document outlines this step in detail.

For FS-28, EDB groundwater concentrations collected at or near the water table in the vicinity of the western bog ditch near the former SWP system were compared to the VI screening values for EDB. Note that a screening value comparison is only applicable when the depth to groundwater at the building being assessed is greater than 5 ft below building foundation level.

K1.4.1 Detached Shallow Lobe in Vicinity of SWPs

Locations that provide EDB groundwater data at or near the water table include piezometer location 69PZ1291A and several of the pushpoint locations sampled below the bog ditch within the vicinity of the SWPs. Table K-3 provides a summary of the EDB data from these locations as compared to the screening values; sampling locations are shown on Figure K-5.

Recent EDB detections in the vicinity of the SWPs near the water table at 69PZ1291A and several pushpoint locations have ranged from below the reporting limit of 0.01 µg/L to a maximum of 0.128 µg/L (at 69DP4103 on 25 July 2008). As shown in Table K-3, all detected EDB concentrations were found to be well below both VI screening values established for EDB. Since this portion of the plume has no ongoing source and concentrations are expected to decline in the future through natural attenuation processes, higher EDB concentrations than those currently detected are not expected in the future.

Note that, in the vicinity of 69PZ1291A and the pushpoint locations, where a clean water lens is sometimes absent, the groundwater table is less than 5 ft bgs. However, the buildings to the west are located in an area of higher elevation away from the banks of the Coonamessett River, with the water table in this area being 5 ft or greater below the foundation depth at these buildings. Therefore, use of the VI screening values given this estimated depth to groundwater is appropriate.

Since EDB concentrations are below the relevant VI screening values, the VI exposure pathway is considered insignificant.

K2.0 CONCLUSIONS AND RECOMMENDATIONS

K2.1 CONCLUSIONS

A review of historic groundwater sampling data indicates that a constantly present clean water lens at least 3 ft thick can be defined for the main body and the southern deep lobe of the FS-28 plume, thus further VI evaluation is not necessary for these areas. However, a consistent 3 ft-thick clean water lens cannot be defined with adequate certainty for the detached shallow plume lobe in the vicinity of the former SWP system. Within that area, sporadic and isolated EDB detections have been observed within 1 to 2 ft of the water table, primarily below the western bog ditch, within the past three years. One residential structure is located approximately 100 ft west of this bog ditch. The EDB groundwater concentrations collected at or near the water table are less than the VI screening values for EDB that have been established for this VI evaluation. Therefore, the VI pathway is considered insignificant in this area and the EDB present in groundwater is considered unlikely to result in VI risks above target levels. Further VI evaluation for this area in the vicinity of the SWPs is not necessary since EDB concentrations are expected to decline as the remnants of the plume naturally attenuate. Additionally, it is acknowledged that isolated low concentration detections of EDB (i.e., sub-MMCL) may be observed in groundwater below, and surface water within, the Coonamessett River and bog system in the future; however, this EDB is unlikely to result in a VI concern due to the combination of the low concentration, limited extent, and very low probability of a complete exposure pathway near the river and bogs.

K2.2 RECOMMENDATIONS

All areas of the FS-28 plume have been evaluated for VI, but it has been concluded that VI concerns are unwarranted based on either an incomplete or insignificant exposure pathway. Therefore, no further monitoring or data collection is needed specific to VI. However, as part of the ongoing remedial actions at FS-28, AFCEE will continue to monitor the nature and extent of the FS-28 plume under the SPEIM program and will re-evaluate the VI exposure pathway if conditions change such that VI could be a concern.

K3.0 REFERENCES

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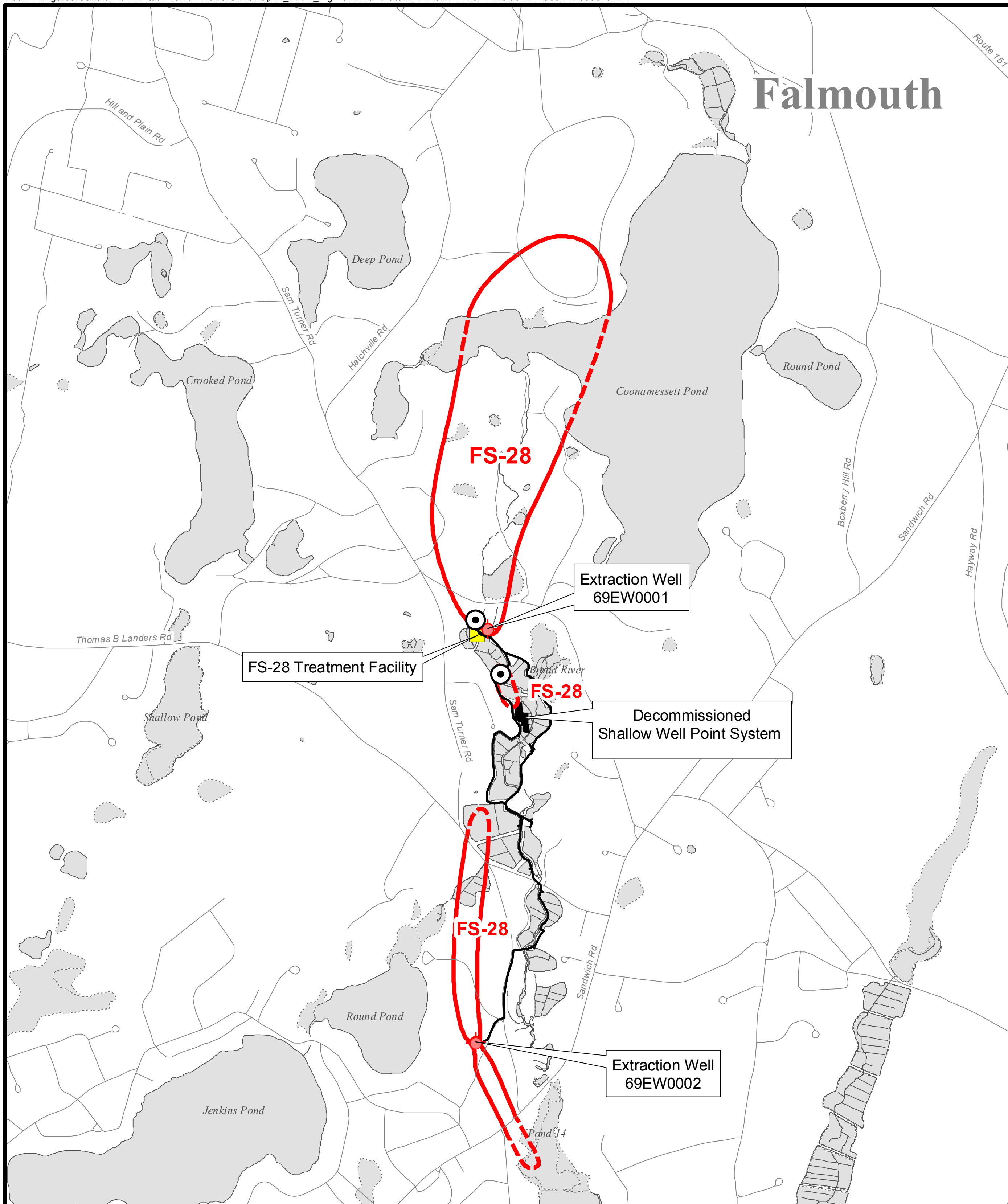

Data Source: AFCEE, May 2011, MMR-AFCEE Data Warehouse

Legend

- FS-28 Plume Boundary (Dashed Where Inferred)
- Bog/Wetland
- Treatment System Piping
- Extraction Well
- Outflow Bubbler
- Treatment Facility

0 740 1,480 Feet

FIGURE K-1

FS-28 GROUNDWATER PLUME AND REMEDIAL SYSTEM

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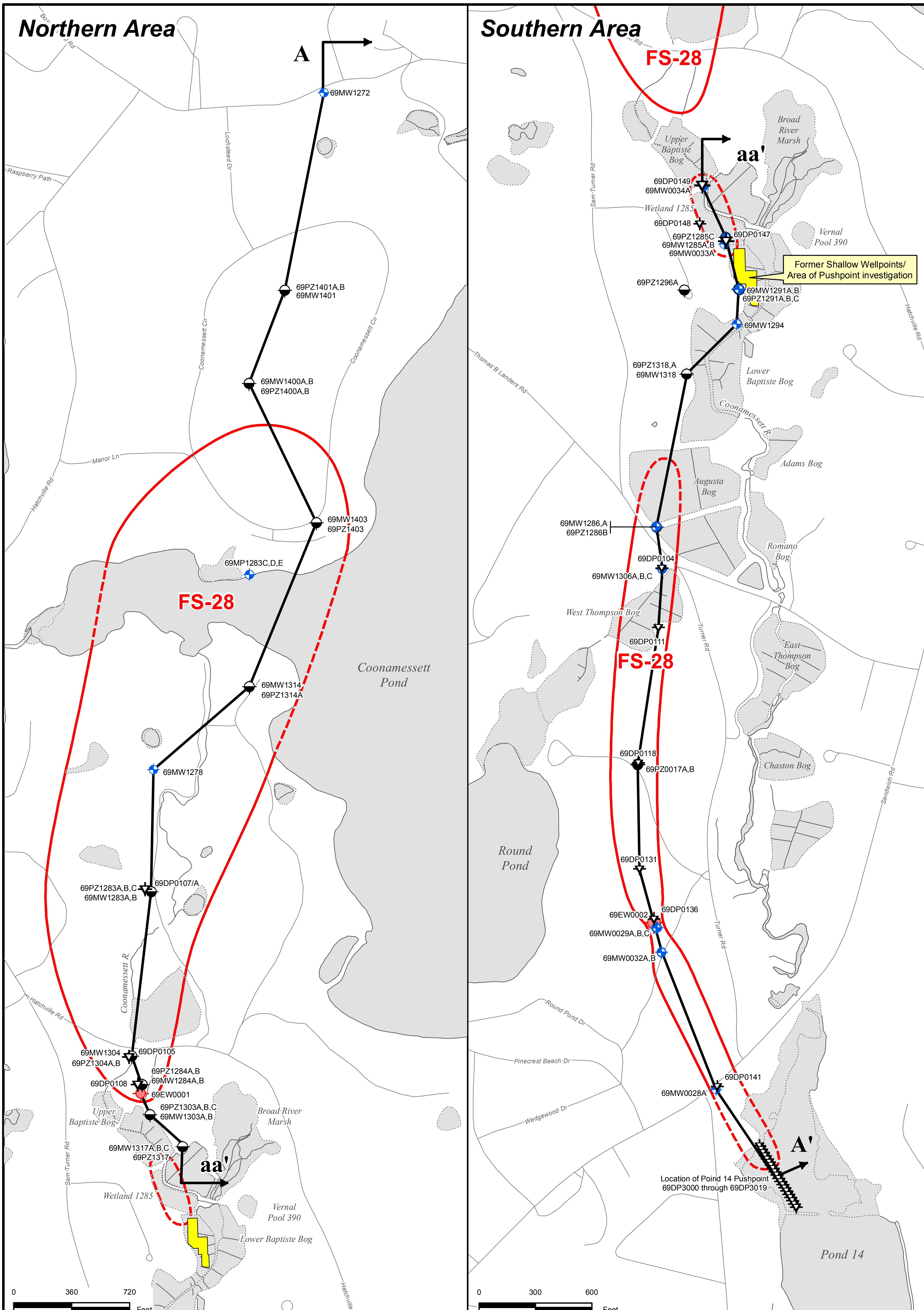

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Data Source: AFCEE, May 2011, MMR-AFCEE Data Warehouse

Legend

- Direct Push Location
- Extraction Well
- Monitoring Well
- Piezometer
- Former Shallow Wellpoints
- Transect
- FS-28 2009 Plume Boundary (Dashed Where Inferred)
- Bog/Wetland

N

FIGURE K-2

FS-28 GROUNDWATER PLUME AND LOCATION OF CROSS-SECTION LINES

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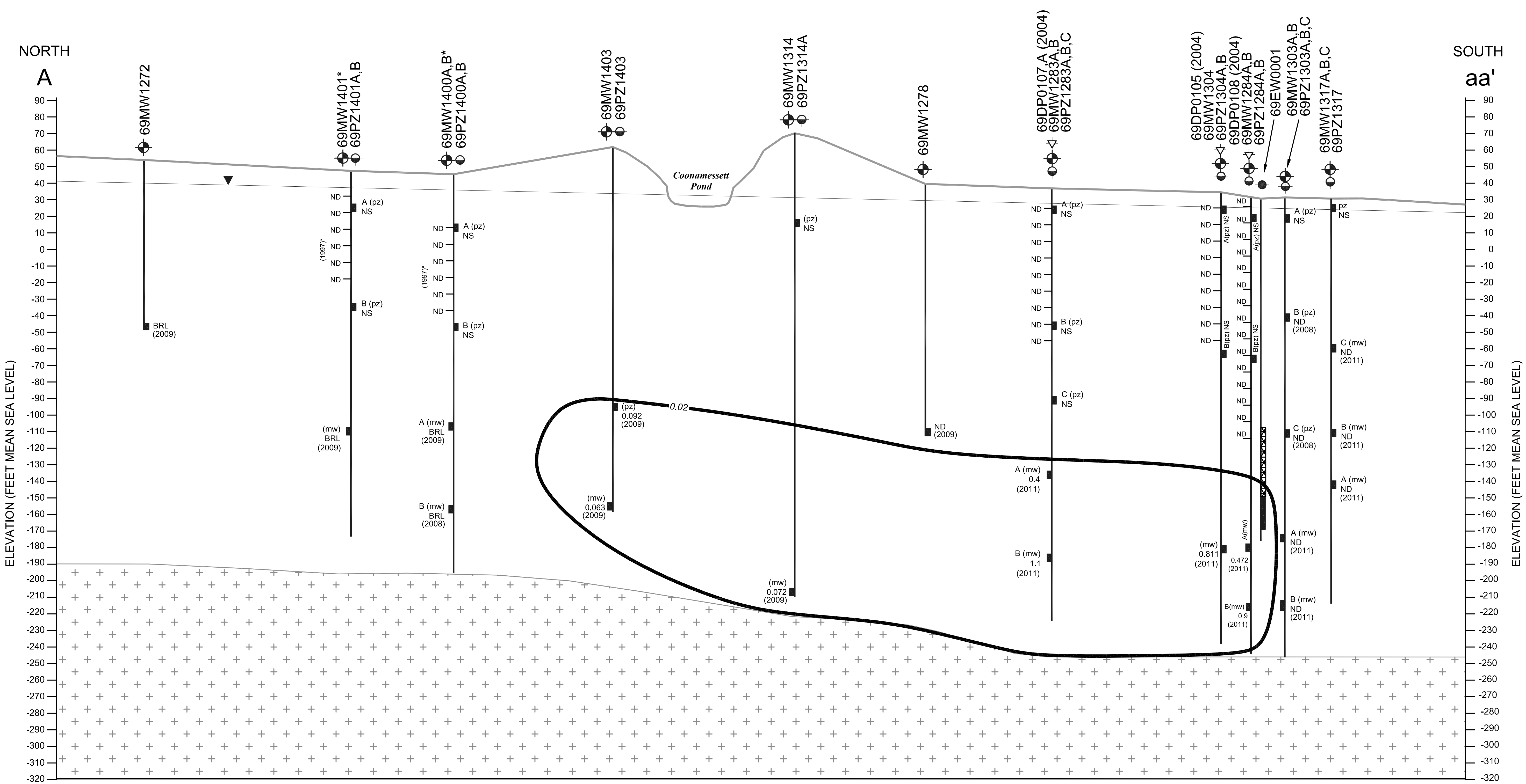

Data Source: AFCEE, May 2011, MMR-AFCEE Data Warehouse.

Legend

Monitoring Well	BRL Below Reporting Limit	12 Monitoring Well EDB Results (µg/L) (Latest Available Data, Date Noted)	Overburden
A Well screen ID	ND Nondetect	0.02 2009 Plume Boundary (MMCL = 0.02 µg/L)	Bedrock
Extraction Well	NS Not Sampled		
Piezometer	Water table	ND	Screen Closed (Packered)

Notes:
1) Data source for vertical profile data at locations 69MW1400A and 69MW1401A is Appendix G, Final Southwest Operable Unit (SWOU) Remedial Investigation. (AFCEE 1999) Data collected in 1997.
2) Data from the shallowest intervals are shown to support VI clean water lens evaluation.

V: 60
H: 600
0 Feet

FIGURE K-3

FS-28 CROSS-SECTION A - aa'

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Final 2011 MMR Vapor Intrusion Evaluation
Technical Memorandum

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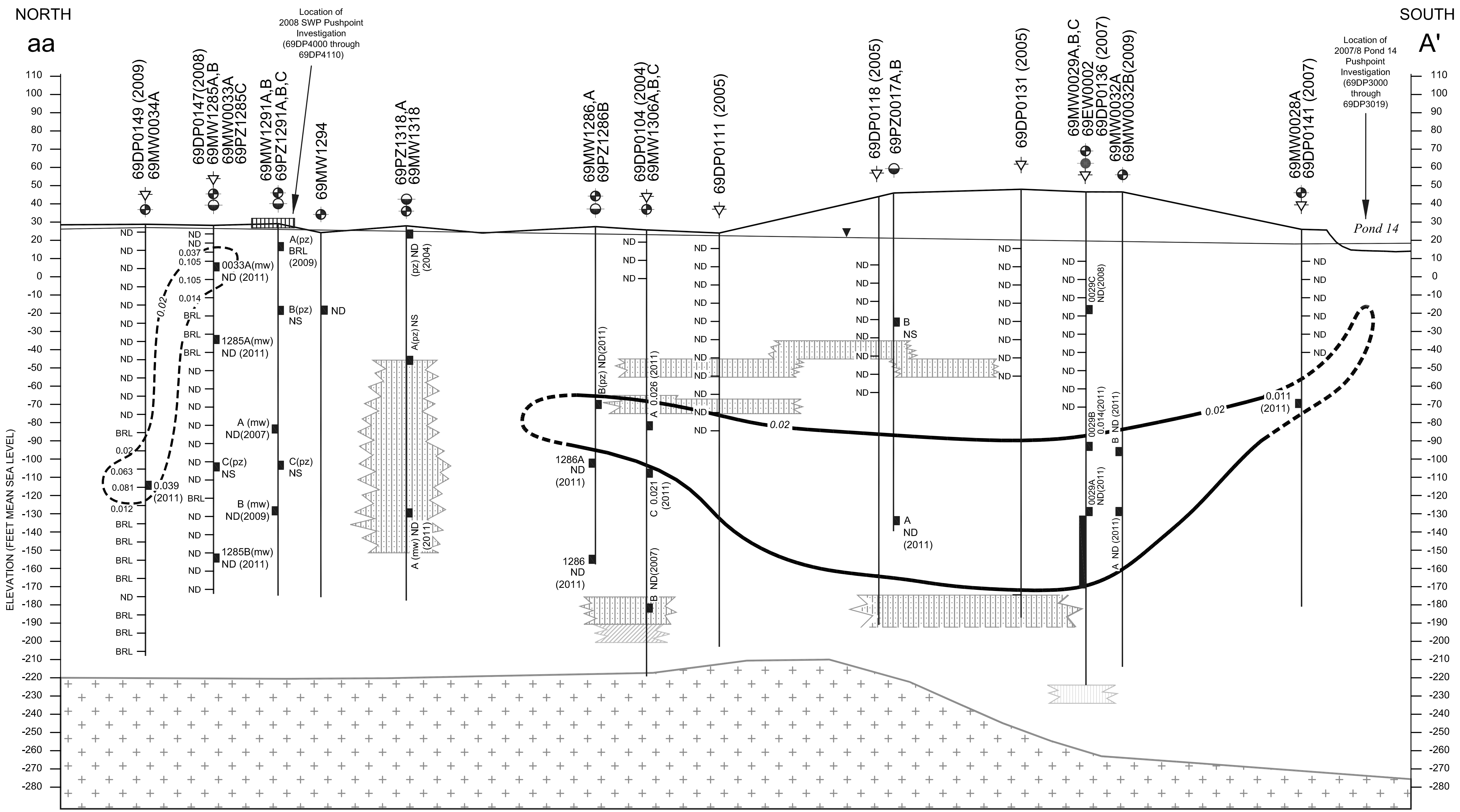

Legend

Monitoring Well	A Well Screen ID	BRL Below Reporting Limit	1.14 EDB Vertical Profile Data (µg/L)(Date Noted)	Silt	
Piezometer	NS Not Sampled	0.02 2009 Plume Boundary (Dashed Where Inferred) (MMCL = 0.02 µg/L)	Clay	Sand	
Extraction Well	ND Nondetect				
Direct Push Location	Water Table	0.162 Monitoring Well EDB Results (µg/L) (Latest Available Data, Date Noted)	Silty Sand	Bedrock	

Data Source: AFCEE, June 2011, MMR AFCEE Data Warehouse

V: 60
H: 480
0
Feet

FIGURE K-4

FS-28 CROSS-SECTION aa'-A'

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Legend

Plume Boundary (Dashed Where Inferred)

Monitoring Well

Piezometer

Direct Push Location

Pushpoint Location - EDB Detected

Pushpoint Location - EDB Not Detected

* Indicates a Pushpoint ID Number in the 69DP4000 Series; Pushpoint investigation conducted between July - November 2008

Data Source: AFCEE, MMR-AFCEE Data Warehouse
2009 Aerial Photography From MassGIS

N

0 40 80 Feet

FIGURE K-5

FS-28 GROUNDWATER PLUME IN VICINITY OF FORMER SHALLOW WELL POINTS

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Table K-1
FS-28 Groundwater Data Used in Support of VI Evaluation
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Location	Date Sampled	Mid-Sample Elevation (ft msl)	Sampling Method[1]	Laboratory Analyses
				EDB (µg/L) MMCL[2] = 0.02
Main Plume Body				
69DP0105	7/22/2004	22	VP	ND
69DP0105	7/22/2004	12	VP	ND
69DP0105	7/22/2004	2	VP	ND
69DP0105	7/22/2004	-8	VP	ND
69DP0105	7/22/2004	-18	VP	ND
69DP0105	7/22/2004	-28	VP	ND
69DP0105	7/22/2004	-38	VP	ND
69DP0105	7/22/2004	-48	VP	ND
69DP0105	7/23/2004	-58	VP	ND
69DP0107	7/30/2004	26	VP	ND
69DP0107	7/30/2004	16	VP	ND
69DP0107	7/30/2004	6	VP	ND
69DP0107	7/30/2004	-4	VP	ND
69DP0107	8/2/2004	-14	VP	ND
69DP0107A	8/2/2004	-24	VP	ND
69DP0107A	8/2/2004	-34	VP	ND
69DP0107A	8/2/2004	-44	VP	ND
69DP0107A	8/3/2004	-54	VP	ND
69DP0108	7/19/2004	21	VP	ND
69DP0108	7/19/2004	11	VP	ND
69DP0108	7/19/2004	1	VP	ND
69DP0108	7/19/2004	-9	VP	ND
69DP0108	7/19/2004	-19	VP	ND
69DP0108	7/19/2004	-29	VP	ND
69DP0108	7/19/2004	-39	VP	ND
69DP0108	7/19/2004	-49	VP	ND
69DP0108	7/20/2004	-59	VP	ND
69DP0108	7/20/2004	-69	VP	ND
69DP0108	7/20/2004	-79	VP	ND
69DP0108	7/20/2004	-89	VP	ND
69DP0108	7/20/2004	-99	VP	ND
69DP0108	7/20/2004	-109	VP	ND
69DP0108	7/20/2004	-119	VP	ND
69MW1400A[3]	1/10/1997	13	VP	ND
69MW1400A[3]	1/10/1997	3	VP	ND
69MW1400A[3]	1/10/1997	-7	VP	ND
69MW1400A[3]	1/13/1997	-17	VP	ND
69MW1400A[3]	1/13/1997	-27	VP	ND
69MW1400A[3]	1/13/1997	-37	VP	ND
69MW1401[3]	1/14/1997	32	VP	ND
69MW1401[3]	1/14/1997	22	VP	ND
69MW1401[3]	1/14/1997	12	VP	ND
69MW1401[3]	1/14/1997	2	VP	ND
69MW1401[3]	1/14/1997	-8	VP	ND
69MW1401[3]	1/14/1997	-18	VP	ND
Detached Shallow Lobe in Vicinity of SWPs				
69DP0147	11/21/2008	22	VP	ND
69DP0147	11/21/2008	17	VP	ND
69DP0147	11/21/2008	12	VP	**0.037**

Table K-1
FS-28 Groundwater Data Used in Support of VI Evaluation
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Location	Date Sampled	Mid-Sample Elevation (ft msl)	Sampling Method[1]	Laboratory Analyses
				EDB (µg/L) MMCL[2] = 0.02
69DP0147	11/21/2008	7	VP	**0.105**
69DP0147	11/24/2008	-3	VP	**0.105**
69DP0147	11/24/2008	-13	VP	0.014
69DP0147	11/24/2008	-23	VP	BRL
69DP0147	11/24/2008	-33	VP	BRL
69DP0147	11/24/2008	-43	VP	BRL
69DP0147	11/24/2008	-53	VP	ND
69DP0147	11/24/2008	-63	VP	ND
69DP0147	11/24/2008	-73	VP	ND
69DP0147	11/26/2008	-83	VP	ND
69DP0147	11/26/2008	-93	VP	ND
69DP0147	11/26/2008	-103	VP	ND
69DP0147	12/1/2008	-113	VP	ND
69DP0147	12/1/2008	-123	VP	BRL
69DP0147	12/1/2008	-133	VP	ND
69DP0147	12/2/2008	-143	VP	ND
69DP0147	12/2/2008	-153	VP	ND
69DP0147	12/2/2008	-163	VP	ND
69DP0147	12/2/2008	-173	VP	ND
69DP0148	12/5/2008	22	VP	ND
69DP0148	12/5/2008	17	VP	ND
69DP0148	12/5/2008	12	VP	ND
69DP0148	12/5/2008	7	VP	ND
69DP0148	1/5/2009	2	VP	ND
69DP0148	1/5/2009	-3	VP	ND
69DP0148	1/5/2009	-8	VP	ND
69DP0148	1/5/2009	-13	VP	ND
69DP0148	1/5/2009	-23	VP	ND
69DP0148	1/5/2009	-33	VP	ND
69DP0148	1/5/2009	-43	VP	ND
69DP0148	1/6/2009	-53	VP	ND
69DP0148	1/6/2009	-63	VP	ND
69DP0148	1/6/2009	-73	VP	ND
69DP0148	1/6/2009	-83	VP	ND
69DP0148	1/6/2009	-93	VP	ND
69DP0148	1/7/2009	-103	VP	ND
69DP0148	1/29/2009	-119	VP	ND
69DP0148	1/29/2009	-129	VP	ND
69DP0148	1/29/2009	-139	VP	ND
69DP0148	1/29/2009	-149	VP	BRL
69DP0148	1/30/2009	-159	VP	0.02
69DP0148	1/30/2009	-169	VP	BRL
69DP0148	1/30/2009	-179	VP	BRL
69DP0149	1/13/2009	23	VP	ND
69DP0149	1/13/2009	13	VP	ND
69DP0149	1/13/2009	3	VP	ND
69DP0149	1/13/2009	-7	VP	ND
69DP0149	1/13/2009	-17	VP	ND
69DP0149	1/13/2009	-27	VP	ND
69DP0149	1/14/2009	-37	VP	ND
69DP0149	1/14/2009	-47	VP	ND
69DP0149	1/14/2009	-57	VP	ND

Table K-1
FS-28 Groundwater Data Used in Support of VI Evaluation
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Location	Date Sampled	Mid-Sample Elevation (ft msl)	Sampling Method[1]	Laboratory Analyses
				EDB (µg/L) MMCL[2] = 0.02
69DP0149	1/14/2009	-67	VP	ND
69DP0149	1/21/2009	-77	VP	ND
69DP0149	1/21/2009	-87	VP	BRL
69DP0149	1/21/2009	-97	VP	0.02
69DP0149	1/21/2009	-107	VP	**0.063**
69DP0149	1/21/2009	-117	VP	**0.081**
69DP0149	1/22/2009	-127	VP	0.012
69DP0149	1/22/2009	-137	VP	BRL
69DP0149	1/22/2009	-147	VP	BRL
69DP0149	1/22/2009	-157	VP	BRL
69DP0149	1/23/2009	-167	VP	BRL
69DP0149	1/23/2009	-177	VP	ND
69DP0149	1/23/2009	-187	VP	BRL
69DP0149	1/23/2009	-197	VP	BRL
69DP0149	1/26/2009	-207	VP	BRL
69DP4001	7/25/2008	26	PP	ND
69DP4002	7/24/2008	26	PP	ND
69DP4003	7/24/2008	26	PP	ND
69DP4004	7/24/2008	26	PP	ND
69DP4005	7/24/2008	26	PP	ND
69DP4006	7/24/2008	26	PP	ND
69DP4007	7/24/2008	26	PP	ND
69DP4008	7/24/2008	26	PP	ND
69DP4009	7/24/2008	26	PP	ND
69DP4010	7/24/2008	26	PP	ND
69DP4011	7/24/2008	26	PP	ND
69DP4012	7/24/2008	26	PP	ND
69DP4013	7/24/2008	26	PP	ND
69DP4014	7/24/2008	26	PP	ND
69DP4015	7/24/2008	26	PP	ND
69DP4016	7/24/2008	26	PP	ND
69DP4017	7/24/2008	26	PP	ND
69DP4018	7/24/2008	26	PP	ND
69DP4019	7/24/2008	26	PP	ND
69DP4020	7/23/2008	26	PP	ND
69DP4021	7/23/2008	26	PP	ND
69DP4022	7/23/2008	26	PP	ND
69DP4023	7/23/2008	26	PP	ND
69DP4024	7/23/2008	26	PP	ND
69DP4025	7/23/2008	26	PP	ND
69DP4026	7/23/2008	26	PP	ND
69DP4027	7/23/2008	26	PP	ND
69DP4028	7/23/2008	26	PP	ND
69DP4029	7/23/2008	26	PP	ND
69DP4030	7/23/2008	26	PP	ND
69DP4031	7/23/2008	26	PP	ND
69DP4032	7/23/2008	26	PP	ND
69DP4033	7/23/2008	26	PP	ND
69DP4034	7/23/2008	26	PP	ND
69DP4035	7/23/2008	26	PP	ND
69DP4036	7/23/2008	26	PP	ND
69DP4037	7/23/2008	26	PP	ND

Table K-1
FS-28 Groundwater Data Used in Support of VI Evaluation
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Location	Date Sampled	Mid-Sample Elevation (ft msl)	Sampling Method[1]	Laboratory Analyses
				EDB (µg/L) MMCL[2] = 0.02
69DP4038	7/23/2008	26	PP	ND
69DP4039	7/23/2008	26	PP	ND
69DP4040	7/22/2008	26	PP	ND
69DP4041	7/22/2008	26	PP	ND
69DP4042	7/22/2008	26	PP	ND
69DP4043	7/22/2008	26	PP	ND
69DP4044	7/22/2008	26	PP	ND
69DP4045	7/22/2008	26	PP	ND
69DP4046	7/22/2008	26	PP	ND
69DP4047	7/22/2008	26	PP	ND
69DP4048	7/22/2008	26	PP	ND
69DP4049	7/22/2008	26	PP	ND
69DP4050	7/22/2008	26	PP	ND
69DP4051	7/22/2008	26	PP	ND
69DP4052	7/22/2008	26	PP	ND
69DP4053	7/22/2008	26	PP	ND
69DP4054	7/22/2008	26	PP	ND
69DP4055	7/22/2008	26	PP	ND
69DP4056	7/22/2008	26	PP	ND
69DP4057	7/22/2008	26	PP	ND
69DP4058	7/22/2008	26	PP	ND
69DP4059	7/22/2008	26	PP	ND
69DP4060	7/22/2008	26	PP	ND
69DP4061	7/22/2008	26	PP	ND
69DP4062	7/21/2008	26	PP	ND
69DP4063	7/21/2008	26	PP	ND
69DP4064	7/21/2008	26	PP	ND
69DP4065	7/21/2008	26	PP	ND
69DP4066	7/21/2008	26	PP	ND
69DP4067	7/21/2008	26	PP	ND
69DP4068	7/21/2008	26	PP	ND
69DP4069	7/21/2008	26	PP	ND
69DP4070	7/21/2008	26	PP	ND
69DP4071	7/21/2008	26	PP	ND
69DP4072	7/21/2008	26	PP	ND
69DP4073	7/21/2008	26	PP	ND
69DP4074	7/21/2008	26	PP	ND
69DP4075	7/21/2008	26	PP	ND
69DP4076	7/21/2008	26	PP	ND
69DP4077	7/21/2008	26	PP	ND
69DP4078	7/21/2008	26	PP	ND
69DP4079	7/21/2008	26	PP	ND
69DP4080	7/21/2008	26	PP	ND
69DP4081	7/21/2008	26	PP	ND
69DP4082	7/25/2008	25	PP	ND
69DP4083	7/25/2008	25	PP	ND
69DP4084	7/25/2008	25	PP	ND
69DP4085	7/24/2008	25	PP	ND
69DP4086	7/25/2008	25	PP	ND
69DP4087	7/25/2008	25	PP	ND
69DP4088	7/25/2008	25	PP	ND
69DP4089	7/25/2008	25	PP	ND

Table K-1
FS-28 Groundwater Data Used in Support of VI Evaluation
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Location	Date Sampled	Mid-Sample Elevation (ft msl)	Sampling Method[1]	Laboratory Analyses
				EDB (µg/L) MMCL[2] = 0.02
69DP4090	7/25/2008	25	PP	ND
69DP4091	7/25/2008	25	PP	ND
69DP4092	7/25/2008	25	PP	ND
69DP4093	7/25/2008	25	PP	ND
69DP4094	7/25/2008	25	PP	BRL
69DP4095	7/25/2008	25	PP	ND
69DP4096	7/25/2008	25	PP	BRL
69DP4097	7/25/2008	25	PP	ND
69DP4098	7/25/2008	25	PP	BRL
69DP4099	7/25/2008	25	PP	ND
69DP4100	7/25/2008	25	PP	ND
69DP4101	7/25/2008	25	PP	BRL
69DP4102	7/25/2008	25	PP	0.01
69DP4102	9/12/2008	25	PP	**0.034**
69DP4102	11/14/2008	25	PP	BRL
69DP4103	7/25/2008	25	PP	**0.128**
69DP4103	9/12/2008	25	PP	**0.021**
69DP4103	11/14/2008	25	PP	ND
69DP4104	7/25/2008	25	PP	BRL
69DP4104	9/12/2008	25	PP	BRL
69DP4104	11/14/2008	25	PP	ND
69DP4105	7/24/2008	25	PP	ND
69DP4106	7/25/2008	25	PP	ND
69DP4107	7/25/2008	25	PP	ND
69DP4108	7/25/2008	26	PP	ND
69DP4108	9/12/2008	26	PP	ND
69DP4108	11/14/2008	26	PP	ND
69DP4109	7/25/2008	26	PP	ND
69DP4110	7/25/2008	26	PP	ND
69MW0033A	6/5/2009	5	MW	BRL
69MW0033A	1/14/2010	5	MW	**0.029**
69MW0033A	2/18/2011	5	MW	ND
69PZ1291A	4/9/2003	17	MW	ND
69PZ1291A	8/27/2003	17	MW	ND
69PZ1291A	9/15/2003	17	MW	ND
69PZ1291A	12/29/2003	17	MW	ND
69PZ1291A	5/12/2004	17	MW	ND
69PZ1291A	7/21/2004	17	MW	ND
69PZ1291A	9/13/2004	17	MW	ND
69PZ1291A	4/13/2007	17	MW	ND
69PZ1291A	7/1/2008	17	MW	ND
69PZ1291A	3/25/2009	17	MW	BRL
69PZ1296A	10/14/2008	21	MW	ND
Southern Deep Lobe				
69DP0104	6/4/2004	19	VP	ND
69DP0104	6/4/2004	9	VP	ND
69DP0104	6/7/2004	-1	VP	ND
69DP0111	4/12/2005	16	VP	ND
69DP0111	4/12/2005	6	VP	ND
69DP0111	4/12/2005	-4	VP	ND
69DP0111	4/12/2005	-14	VP	ND
69DP0111	4/12/2005	-24	VP	ND

Table K-1
FS-28 Groundwater Data Used in Support of VI Evaluation
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Location	Date Sampled	Mid-Sample Elevation (ft msl)	Sampling Method[1]	Laboratory Analyses
				EDB (µg/L) MMCL[2] = 0.02
69DP0111	4/12/2005	-34	VP	ND
69DP0111	4/13/2005	-44	VP	ND
69DP0111	4/13/2005	-54	VP	ND
69DP0111	4/13/2005	-64	VP	ND
69DP0111	4/13/2005	-74	VP	ND
69DP0111	4/13/2005	-84	VP	ND
69DP0118	6/29/2005	7	VP	ND
69DP0118	6/29/2005	-3	VP	ND
69DP0118	6/29/2005	-13	VP	ND
69DP0118	6/29/2005	-23	VP	ND
69DP0118	6/29/2005	-33	VP	ND
69DP0118	6/29/2005	-43	VP	ND
69DP0118	6/30/2005	-53	VP	ND
69DP0118	6/30/2005	-63	VP	ND
69DP0131	11/29/2005	16	VP	ND
69DP0131	11/29/2005	6	VP	ND
69DP0131	11/29/2005	-4	VP	ND
69DP0131	11/29/2005	-14	VP	ND
69DP0131	11/29/2005	-24	VP	ND
69DP0131	11/29/2005	-34	VP	ND
69DP0131	11/30/2005	-44	VP	ND
69DP0131	11/30/2005	-54	VP	ND
69DP0136	1/23/2007	9	VP	ND
69DP0136	1/23/2007	-1	VP	ND
69DP0136	1/24/2007	-11	VP	ND
69DP0136	1/24/2007	-21	VP	ND
69DP0136	1/24/2007	-31	VP	ND
69DP0136	1/24/2007	-41	VP	ND
69DP0136	1/24/2007	-51	VP	ND
69DP0136	1/24/2007	-61	VP	ND
69DP0136	1/24/2007	-71	VP	ND
69DP0141	3/15/2007	9	VP	ND
69DP0141	3/15/2007	-1	VP	ND
69DP0141	3/15/2007	-11	VP	ND
69DP0141	3/19/2007	-21	VP	ND
69DP0141	3/19/2007	-31	VP	ND
69DP0141	3/19/2007	-41	VP	ND
69DP3000	12/28/2007	17	PP	ND
69DP3001	12/28/2007	17	PP	ND
69DP3002	12/28/2007	17	PP	ND
69DP3003	12/28/2007	17	PP	ND
69DP3004	12/28/2007	17	PP	ND
69DP3005	12/28/2007	17	PP	ND
69DP3006	12/28/2007	17	PP	ND
69DP3007	12/28/2007	17	PP	ND
69DP3008	12/28/2007	17	PP	ND
69DP3009	12/28/2007	17	PP	ND
69DP3010	1/2/2008	17	PP	ND
69DP3011	1/2/2008	17	PP	ND
69DP3012	1/2/2008	17	PP	ND
69DP3013	1/2/2008	17	PP	ND
69DP3014	1/2/2008	17	PP	ND

Table K-1
FS-28 Groundwater Data Used in Support of VI Evaluation
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Location	Date Sampled	Mid-Sample Elevation (ft msl)	Sampling Method[1]	Laboratory Analyses
				EDB (µg/L) MMCL[2] = 0.02
69DP3015	1/8/2008	17	PP	ND
69DP3016	1/8/2008	17	PP	ND
69DP3017	1/8/2008	17	PP	ND
69DP3018	1/8/2008	17	PP	ND
69DP3019	1/8/2008	17	PP	ND

Data Source: AFCEE, May 2011, MMR-AFCEE Data Warehouse

Notes:

1. Sample collection methodology:
   PP = pushpoint sampler
   VP = vertical profile groundwater sampling (direct push, rotosonic, or screened hollow-stem auger methods)
   MW = fixed monitoring well
2. Groundwater MMCL from Massachusetts Department of Environmental Protection (MassDEP) web page, http://www.mass.gov/dep/water/dwstand.pdf.

Vertical profile data from locations 69MW1400A and 69MW1401 obtained from the "Final Southwest Operable Unit (SWOU) Remedial Investigation Report", Appendix G (AFCEE 1999).

The data summarized in this table specifically support the FS-28 VI clean water lens and screening evaluation and include the sampling results for each location for the plume-related VI COPCs only (i.e., EDB). If additional historic sampling data exist, they are available for review in the AFCEE-MMR Data Warehouse.

Vertical profile data presented only included the relevant sample intervals used to support the FS-28 VI clean water lens and screening evaluation; if analytical data from deeper sample intervals exist, they are available for review in the AFCEE MMR Data Warehouse.

Bold values represent EDB concentrations above the MMCL.

Key:

BRL = below reporting limit	MMCL = Massachusetts Maximum Contaminant Level
EDB = ethylene dibromide	ND = not detected
FS-28 = Fuel Spill-28	µg/L = micrograms per liter
ft msl = feet mean sea level	

Table K-2
FS-28 Well Construction and Sample Location Information
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Location	Northing (ft)	Easting (ft)	Surface Elevation (ft msl)	Measuring Point Elevation (ft msl)	Total Well Depth (ft bgs)	Top Screen Depth (ft bgs)	Bottom Screen Depth (ft bgs)	Top Screen Elevation (ft msl)	Bottom Screen Elevation (ft msl)	Screen Length (ft)
Main Plume Body										
69MW0033A	223500	853476	28	27.53	26	18.90	24.80	7.92	2.92	5
69DP0105	224467	853161	31	NA[1]	NA[1]	NA[1]	NA[1]	NA[1]	NA[1]	NA[1]
69DP0107	225507	853261	38	NA[1]	NA[1]	NA[1]	NA[1]	NA[1]	NA[1]	NA[1]
69DP0107A	225505	853260	38	NA[1]	NA[1]	NA[1]	NA[1]	NA[1]	NA[1]	NA[1]
69DP0108	224296	853217	29	NA[1]	NA[1]	NA[1]	NA[1]	NA[1]	NA[1]	NA[1]
69MW1400A	228652	853906	46	45.40	155	150.00	155.00	-104.37	-109.37	5
69MW1400B	228652	853906	46	45.37	205	200.00	205.00	-154.37	-159.37	5
69MW1401	229230	854128	48	47.16	160	155.00	160.00	-107.32	-112.32	5
Detached Shallow Lobe in Vicinity of Former SWPs										
69DP0147	223509	853486	26	NA[1]	NA[1]	NA[1]	NA[1]	NA[1]	NA[1]	NA[1]
69DP0148	223601	853346	26	NA[1]	NA[1]	NA[1]	NA[1]	NA[1]	NA[1]	NA[1]
69DP0149	223806	853359	27	NA[1]	NA[1]	NA[1]	NA[1]	NA[1]	NA[1]	NA[1]
69DP4001	223465	853536	26	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4002	223466	853556	26	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4003	223467	853576	26	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4004	223456	853546	26	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4005	223457	853567	26	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4006	223446	853537	26	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4007	223446	853557	26	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4008	223447	853577	26	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4009	223436	853547	26	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4010	223437	853567	26	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4011	223426	853537	26	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4012	223427	853557	26	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4013	223427	853577	26	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4014	223416	853547	26	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4015	223417	853567	26	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4016	223406	853537	26	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4017	223406	853557	26	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4018	223407	853578	26	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4019	223397	853547	26	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4020	223397	853567	26	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4021	223387	853538	26	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4022	223386	853557	26	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4023	223377	853547	26	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4024	223366	853537	26	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4025	223367	853557	26	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4026	223367	853578	26	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4027	223357	853548	26	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4028	223357	853568	26	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4029	223346	853538	26	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4030	223347	853558	26	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4031	223347	853579	26	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4032	223348	853600	26	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4033	223348	853619	26	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4034	223349	853640	26	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]

Table K-2
FS-28 Well Construction and Sample Location Information
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Location	Northing (ft)	Easting (ft)	Surface Elevation (ft msl)	Measuring Point Elevation (ft msl)	Total Well Depth (ft bgs)	Top Screen Depth (ft bgs)	Bottom Screen Depth (ft bgs)	Top Screen Elevation (ft msl)	Bottom Screen Elevation (ft msl)	Screen Length (ft)
69DP4035	223337	853548	26	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4036	223337	853569	26	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4037	223337	853590	26	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4038	223338	853610	26	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4039	223339	853630	26	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4040	223326	853538	26	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4041	223327	853558	26	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4042	223327	853580	26	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4043	223328	853600	26	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4044	223328	853620	26	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4045	223329	853640	26	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4046	223317	853548	26	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4047	223317	853569	26	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4048	223317	853590	26	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4049	223318	853610	26	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4050	223318	853630	26	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4051	223307	853558	26	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4052	223307	853580	26	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4053	223308	853600	26	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4054	223308	853620	26	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4055	223309	853640	26	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4056	223297	853569	26	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4057	223298	853591	26	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4058	223298	853610	26	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4059	223299	853630	26	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4060	223288	853600	26	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4061	223288	853620	26	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4062	223289	853641	26	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4063	223278	853611	26	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4064	223279	853630	26	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4065	223268	853601	26	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4066	223268	853621	26	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4067	223269	853641	26	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4068	223258	853611	26	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4069	223258	853631	26	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4070	223229	853621	26	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4071	223229	853641	26	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4072	223219	853631	26	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4073	223219	853651	26	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4074	223209	853621	26	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4075	223209	853641	26	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4076	223199	853631	26	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4077	223199	853651	26	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4078	223189	853621	26	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4079	223190	853641	26	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4080	223180	853631	26	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4081	223180	853651	26	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4082	223110	853606	25	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]

Table K-2
FS-28 Well Construction and Sample Location Information
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Location	Northing (ft)	Easting (ft)	Surface Elevation (ft msl)	Measuring Point Elevation (ft msl)	Total Well Depth (ft bgs)	Top Screen Depth (ft bgs)	Bottom Screen Depth (ft bgs)	Top Screen Elevation (ft msl)	Bottom Screen Elevation (ft msl)	Screen Length (ft)
69DP4083	223124	853592	25	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4084	223140	853579	25	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4085	223160	853579	25	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4086	223179	853583	25	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4087	223201	853584	25	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4088	223219	853581	25	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4089	223238	853575	25	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4090	223256	853566	25	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4091	223273	853555	25	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4092	223290	853544	25	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4093	223305	853531	25	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4094	223322	853521	25	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4095	223340	853512	25	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4096	223359	853506	25	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4097	223379	853502	25	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4098	223399	853501	25	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4099	223418	853502	25	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4100	223438	853500	25	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4101	223458	853494	25	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4102	223477	853489	25	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4103	223497	853489	25	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4104	223498	853513	25	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4105	223499	853540	25	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4106	223498	853558	25	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4107	223498	853577	25	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4108	223477	853514	26	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4109	223460	853513	26	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP4110	223439	853517	26	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69MW0033A	223500	853476	28	27.53	25	19.80	24.80	7.92	2.92	5
69PZ1291A	223262	853552	29	28.83	15	10.00	15.00	19.03	14.03	5
69PZ1296A	223257	853264	38	37.98	20	14.50	19.50	23.75	18.75	5
Southern Deep Lobe										
69DP0104	221771	853144	26	NA[1]	NA[1]	NA[1]	NA[1]	NA[1]	NA[1]	NA[1]
69DP0111	221457	853125	24	NA[1]	NA[1]	NA[1]	NA[1]	NA[1]	NA[1]	NA[1]
69DP0118	220736	853018	44	NA[1]	NA[1]	NA[1]	NA[1]	NA[1]	NA[1]	NA[1]
69DP0131	220173	853026	48	NA[1]	NA[1]	NA[1]	NA[1]	NA[1]	NA[1]	NA[1]
69DP0136	219906	853102	41	NA[1]	NA[1]	NA[1]	NA[1]	NA[1]	NA[1]	NA[1]
69DP0141	219017	853438	26	NA[1]	NA[1]	NA[1]	NA[1]	NA[1]	NA[1]	NA[1]
69DP3000	218701	853663	17	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP3001	218684	853673	17	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP3002	218667	853684	17	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP3003	218649	853694	17	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP3004	218632	853704	17	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP3005	218615	853715	17	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP3006	218598	853725	17	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP3007	218581	853735	17	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP3008	218564	853746	17	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP3009	218547	853756	17	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]

Table K-2
FS-28 Well Construction and Sample Location Information
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Location	Northing (ft)	Easting (ft)	Surface Elevation (ft msl)	Measuring Point Elevation (ft msl)	Total Well Depth (ft bgs)	Top Screen Depth (ft bgs)	Bottom Screen Depth (ft bgs)	Top Screen Elevation (ft msl)	Bottom Screen Elevation (ft msl)	Screen Length (ft)
69DP3010	218529	853766	17	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP3011	218512	853776	17	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP3012	218495	853787	17	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP3013	218478	853797	17	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP3014	218461	853807	17	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP3015	218444	853818	17	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP3016	218427	853828	17	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP3017	218410	853838	17	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP3018	218392	853849	17	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
69DP3019	218375	853859	17	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]

Data Source: AFCEE, May 2011, MMR-AFCEE Data Warehouse

Key:
bgs = below ground surface
FS-28 = Fuel Spill-28
ft = feet
msl = mean sea level
N/A = data not available
NA[1] = locations are direct push vertical profile locations and have no screens
NA[2] = locations are push point locations and have no screens
* = estimated data

Table K-3
Comparison of EDB Concentrations in Shallow Groundwater to VI Screening Values
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Location	Date	Mid-Sample Elevation (ft msl)	Laboratory Analyses EDB (µg/L) MMCL[1] = 0.02	MCP Method 1 GW-2 Standard[2] (µg/L)	VI Screening Value Exceeded?	Generic Unrestricted Groundwater VI Screening Value[3] (µg/L)	VI Screening Value Exceeded?
69DP4001	7/25/2008	26.25	ND	2	No	0.38	No
69DP4002	7/24/2008	26.25	ND	2	No	0.38	No
69DP4003	7/24/2008	26.25	ND	2	No	0.38	No
69DP4004	7/24/2008	26.25	ND	2	No	0.38	No
69DP4005	7/24/2008	26.25	ND	2	No	0.38	No
69DP4006	7/24/2008	26.25	ND	2	No	0.38	No
69DP4007	7/24/2008	26.25	ND	2	No	0.38	No
69DP4008	7/24/2008	26.25	ND	2	No	0.38	No
69DP4009	7/24/2008	26.25	ND	2	No	0.38	No
69DP4010	7/24/2008	26.25	ND	2	No	0.38	No
69DP4011	7/24/2008	26.25	ND	2	No	0.38	No
69DP4012	7/24/2008	26.25	ND	2	No	0.38	No
69DP4013	7/24/2008	26.25	ND	2	No	0.38	No
69DP4014	7/24/2008	26.25	ND	2	No	0.38	No
69DP4015	7/24/2008	26.25	ND	2	No	0.38	No
69DP4016	7/24/2008	26.25	ND	2	No	0.38	No
69DP4017	7/24/2008	26.25	ND	2	No	0.38	No
69DP4018	7/24/2008	26.25	ND	2	No	0.38	No
69DP4019	7/24/2008	26.25	ND	2	No	0.38	No
69DP4020	7/23/2008	26.25	ND	2	No	0.38	No
69DP4021	7/23/2008	26.25	ND	2	No	0.38	No
69DP4022	7/23/2008	26.25	ND	2	No	0.38	No
69DP4023	7/23/2008	26.25	ND	2	No	0.38	No
69DP4024	7/23/2008	26.25	ND	2	No	0.38	No
69DP4025	7/23/2008	26.25	ND	2	No	0.38	No
69DP4026	7/23/2008	26.25	ND	2	No	0.38	No
69DP4027	7/23/2008	26.25	ND	2	No	0.38	No
69DP4028	7/23/2008	26.25	ND	2	No	0.38	No
69DP4029	7/23/2008	26.25	ND	2	No	0.38	No
69DP4030	7/23/2008	26.25	ND	2	No	0.38	No
69DP4031	7/23/2008	26.25	ND	2	No	0.38	No
69DP4032	7/23/2008	26.25	ND	2	No	0.38	No
69DP4033	7/23/2008	26.25	ND	2	No	0.38	No
69DP4034	7/23/2008	26.25	ND	2	No	0.38	No
69DP4035	7/23/2008	26.25	ND	2	No	0.38	No
69DP4036	7/23/2008	26.25	ND	2	No	0.38	No
69DP4037	7/23/2008	26.25	ND	2	No	0.38	No
69DP4038	7/23/2008	26.25	ND	2	No	0.38	No
69DP4039	7/23/2008	26.25	ND	2	No	0.38	No
69DP4040	7/22/2008	26.25	ND	2	No	0.38	No
69DP4041	7/22/2008	26.25	ND	2	No	0.38	No
69DP4042	7/22/2008	26.25	ND	2	No	0.38	No
69DP4043	7/22/2008	26.25	ND	2	No	0.38	No
69DP4044	7/22/2008	26.25	ND	2	No	0.38	No
69DP4045	7/22/2008	26.25	ND	2	No	0.38	No
69DP4046	7/22/2008	26.25	ND	2	No	0.38	No
69DP4047	7/22/2008	26.25	ND	2	No	0.38	No
69DP4048	7/22/2008	26.25	ND	2	No	0.38	No
69DP4049	7/22/2008	26.25	ND	2	No	0.38	No
69DP4050	7/22/2008	26.25	ND	2	No	0.38	No

Table K-3
Comparison of EDB Concentrations in Shallow Groundwater to VI Screening Values
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Location	Date	Mid-Sample Elevation (ft msl)	Laboratory Analyses EDB (µg/L) MMCL[1] = 0.02	MCP Method 1 GW-2 Standard[2] (µg/L)	VI Screening Value Exceeded?	Generic Unrestricted Groundwater VI Screening Value[3] (µg/L)	VI Screening Value Exceeded?
69DP4051	7/22/2008	26.25	ND	2	No	0.38	No
69DP4052	7/22/2008	26.25	ND	2	No	0.38	No
69DP4053	7/22/2008	26.25	ND	2	No	0.38	No
69DP4054	7/22/2008	26.25	ND	2	No	0.38	No
69DP4055	7/22/2008	26.25	ND	2	No	0.38	No
69DP4056	7/22/2008	26.25	ND	2	No	0.38	No
69DP4057	7/22/2008	26.25	ND	2	No	0.38	No
69DP4058	7/22/2008	26.25	ND	2	No	0.38	No
69DP4059	7/22/2008	26.25	ND	2	No	0.38	No
69DP4060	7/22/2008	26.25	ND	2	No	0.38	No
69DP4061	7/22/2008	26.25	ND	2	No	0.38	No
69DP4062	7/21/2008	26.25	ND	2	No	0.38	No
69DP4063	7/21/2008	26.25	ND	2	No	0.38	No
69DP4064	7/21/2008	26.25	ND	2	No	0.38	No
69DP4065	7/21/2008	26.25	ND	2	No	0.38	No
69DP4066	7/21/2008	26.25	ND	2	No	0.38	No
69DP4067	7/21/2008	26.25	ND	2	No	0.38	No
69DP4068	7/21/2008	26.25	ND	2	No	0.38	No
69DP4069	7/21/2008	26.25	ND	2	No	0.38	No
69DP4070	7/21/2008	26.25	ND	2	No	0.38	No
69DP4071	7/21/2008	26.25	ND	2	No	0.38	No
69DP4072	7/21/2008	26.25	ND	2	No	0.38	No
69DP4073	7/21/2008	26.25	ND	2	No	0.38	No
69DP4074	7/21/2008	26.25	ND	2	No	0.38	No
69DP4075	7/21/2008	26.25	ND	2	No	0.38	No
69DP4076	7/21/2008	26.25	ND	2	No	0.38	No
69DP4077	7/21/2008	26.25	ND	2	No	0.38	No
69DP4078	7/21/2008	26.25	ND	2	No	0.38	No
69DP4079	7/21/2008	26.25	ND	2	No	0.38	No
69DP4080	7/21/2008	26.25	ND	2	No	0.38	No
69DP4081)	7/21/2008	26.25	ND	2	No	0.38	No
69DP4082	7/25/2008	24.75	ND	2	No	0.38	No
69DP4083	7/25/2008	24.75	ND	2	No	0.38	No
69DP4084	7/25/2008	24.75	ND	2	No	0.38	No
69DP4085	7/24/2008	24.75	ND	2	No	0.38	No
69DP4086	7/25/2008	24.75	ND	2	No	0.38	No
69DP4087	7/25/2008	24.75	ND	2	No	0.38	No
69DP4088	7/25/2008	24.75	ND	2	No	0.38	No
69DP4089	7/25/2008	24.75	ND	2	No	0.38	No
69DP4090	7/25/2008	24.75	ND	2	No	0.38	No
69DP4091	7/25/2008	24.75	ND	2	No	0.38	No
69DP4092	7/25/2008	24.75	ND	2	No	0.38	No
69DP4093	7/25/2008	24.75	ND	2	No	0.38	No
69DP4094	7/25/2008	24.75	BRL	2	No	0.38	No
69DP4095	7/25/2008	24.75	ND	2	No	0.38	No
69DP4096	7/25/2008	24.75	0.003	2	No	0.38	No
69DP4097	7/25/2008	24.75	ND	2	No	0.38	No
69DP4098	7/25/2008	24.75	BRL	2	No	0.38	No
69DP4099	7/25/2008	24.75	ND	2	No	0.38	No
69DP4100	7/25/2008	24.75	ND	2	No	0.38	No

Table K-3
Comparison of EDB Concentrations in Shallow Groundwater to VI Screening Values
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Location	Date	Mid-Sample Elevation (ft msl)	Laboratory Analyses	MCP Method 1 GW-2 Standard[2] (µg/L)	VI Screening Value Exceeded?	Generic Unrestricted Groundwater VI Screening Value[3] (µg/L)	VI Screening Value Exceeded?
			EDB (µg/L) MMCL[1] = 0.02				
69DP4101	7/25/2008	24.75	BRL	2	No	0.38	No
69DP4102	7/25/2008	24.75	0.01	2	No	0.38	No
69DP4102	9/12/2008	24.75	**0.034**	2	No	0.38	No
69DP4102	11/14/2008	24.75	BRL	2	No	0.38	No
69DP4103	7/25/2008	24.75	**0.128**	2	No	0.38	No
69DP4103	9/12/2008	24.75	**0.021**	2	No	0.38	No
69DP4103	11/14/2008	24.75	ND	2	No	0.38	No
69DP4104	7/25/2008	24.75	BRL	2	No	0.38	No
69DP4104	9/12/2008	24.75	BRL	2	No	0.38	No
69DP4104	11/14/2008	24.75	ND	2	No	0.38	No
69DP4105	7/24/2008	24.75	ND	2	No	0.38	No
69DP4106	7/25/2008	24.75	ND	2	No	0.38	No
69DP4107	7/25/2008	24.75	ND	2	No	0.38	No
69DP4108	7/25/2008	26.25	ND	2	No	0.38	No
69DP4108	9/12/2008	26.25	ND	2	No	0.38	No
69DP4108	11/14/2008	26.25	ND	2	No	0.38	No
69DP4109	7/25/2008	26.25	ND	2	No	0.38	No
69DP4110	7/25/2008	26.25	ND	2	No	0.38	No
69PZ1291A	4/9/2003	16.53	ND	2	No	0.38	No
69PZ1291A	8/27/2003	16.53	ND	2	No	0.38	No
69PZ1291A	9/15/2003	16.53	ND	2	No	0.38	No
69PZ1291A	12/29/2003	16.53	ND	2	No	0.38	No
69PZ1291A	5/12/2004	16.53	ND	2	No	0.38	No
69PZ1291A	7/21/2004	16.53	ND	2	No	0.38	No
69PZ1291A	9/13/2004	16.53	ND	2	No	0.38	No
69PZ1291A	4/13/2007	16.53	ND	2	No	0.38	No
69PZ1291A	7/1/2008	16.53	ND	2	No	0.38	No
69PZ1291A	3/25/2009	16.53	BRL	2	No	0.38	No
69PZ1296A	10/14/2008	21.25	ND	2	No	0.38	No

Data Source: AFCEE, May 2012, MMR-AFCEE Data Warehouse

Notes:
1. MMCL from Massachusetts Department of Environmental Protection (MassDEP) web page, http://www.mass.gov/dep/water/dwstand.pdf.
2. 310 CMR 40.0974(2) http://www.mass.gov/dep/cleanup/laws/0974_2.htm .
3. EPA, 2002, Draft Guidance for Evaluating the VI to Indoor Air Pathway from Groundwater and Soils http://www.epa.gov/osw/hazard/correctiveaction/eis/vapor/complete.pdf, using target risk levels of 1×10^{-6} excess lifetime cancer risk and noncancer hazard quotient of 0.1 in accordance with best practices for vapor intrusion screening to account for cumulative effects from multiple chemicals. Values updated based on EPA's May 2012 Regional Screening Levels (Residential Indoor Air) for Chemical Contaminants at Superfund Sites http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm.

Bold values represent EDB concentrations above the MMCL.

Key:

BRL = below reporting limit
ND = not detected
EDB = ethylene dibromide
VI = vapor intrusion
FS-28 = Fuel Spill-28
µg/L = micrograms per liter
MMCL = Massachusetts Maximum Contaminant Level

APPENDIX L

FS-29 Vapor Intrusion Evaluation

TABLE OF CONTENTS

Figures

Tables

ACRONYMS AND ABBREVIATIONS

AFCEE	Air Force Center for Engineering and the Environment
bgs	below ground surface
COC	contaminant of concern
CS	Chemical Spill
CSM	Conceptual Site Model
EDB	ethylene dibromide
FS	Fuel Spill
ft	feet/foot
HATF	Hunter Avenue Treatment Facility
LTM	long term monitoring
MCL	Maximum Contaminant Level
MMCL	Massachusetts MCL
MMR	Massachusetts Military Reservation
MPP	Mashpee Pitted Plain
msl	mean sea level
SPEIM	System Performance and Ecological Impact Monitoring
VI	vapor intrusion
VOC	volatile organic compound
μg/L	micrograms per liter

L1.0 FUEL SPILL-29 VAPOR INTRUSION EVALUATION

L1.1 FS-29 CONCEPTUAL SITE MODEL

The Fuel Spill–29 (FS-29) groundwater plume is a dilute dissolved-phase groundwater plume located south of the Massachusetts Military Reservation (MMR) in Falmouth, Massachusetts (Figure 1-2 of main document), which is detached from its source area. The FS-29 plume (Figure L-1) is currently defined as the extent of groundwater containing the primary groundwater contaminant of concern (COC), ethylene dibromide (EDB), at concentrations greater than the Massachusetts Maximum Contaminant Level (MMCL) of 0.02 micrograms per liter (µg/L). Carbon tetrachloride is also a COC at FS-29; however, detections higher than the Maximum Contaminant Level (MCL) of 5 µg/L are extremely limited in extent.

The location of the source area for the FS-29 plume is unknown; however, the plume most likely originated in the southern portion of the MMR (Figure L-1). The FS-29 plume was first detected in 1998 during an investigation of an area southwest of the MMR (AFCEE 2000). Although the specific source of the FS-29 plume has not been identified, potential source areas hydraulically upgradient of the FS-29 plume were investigated and remediated (if needed) through the Installation Restoration Program in accordance with the established regulatory framework for the MMR sites (AFCEE 2008a, 2008b).

A plan view of the FS-29 plume, along with the location of the line of cross-section and monitoring locations used to support this vapor intrusion (VI) evaluation, are shown on Figure L-2. A cross-sectional view of the FS-29 EDB plume is provided as Figure L-3.

Based on the most recent depiction of the FS-29 plume boundary, the plume extends from the area near the intersections of Route 151, Sam Turner Road and Boxberry Hill Road approximately 5,500 feet (ft) to extraction wells 80EW0001 and 80EW0002 on Falmouth Woods Road, and has a maximum width of approximately 850 ft (Figure L-2). Characteristic of many of the MMR groundwater plumes, the FS-29 plume descended in the aquifer as it migrated from its source area due to recharge accretion, which has resulted in the plume being located relatively deep in the aquifer and entirely overlain by a lens of clean groundwater. The FS-29 plume is up

to approximately 50 ft thick, and the upper boundary of the plume is approximately 180 ft below ground surface (bgs) and approximately 110 ft below the water table (Figure L-3). The depiction of the plume shown in cross-sectional view on Figure L-3 is based on data collected in 2011, whereas the plume boundary shown on Figures L-1 and L-2 is based on data collected in 2010.

The topography of the land above the FS-29 plume footprint is generally flat with a ground elevation change of approximately 20 ft from east to west. Sub-regionally, the area is characterized by low rolling hills and flat areas of the Mashpee Pitted Plain (MPP), which is a broad, flat, gently southward-sloping glacial outwash plain. The trailing edge and main body of the FS-29 plume lies within the MPP. The leading edge of the plume, where the FS-29 remedial system extraction wells are located, travels into the Buzzards Bay Moraine, which is a hummocky north-south trending ridge of moraine glacial deposits (AFCEE 2000). Within the 2010 footprint of the plume, the maximum and minimum ground surface elevations are approximately 182 ft mean sea level (msl), and 50 ft msl, respectively.

The groundwater flow direction in the vicinity of the FS-29 plume is generally to the southwest and flow within the aquifer is primarily horizontal. The depth to water in the vicinity of the FS-29 plume ranges from approximately 70 to 80 ft bgs; the elevation of the water table within the FS-29 area ranges from approximately 40 ft msl in the southwest to 45 ft msl in the northeast. The aquifer saturated thickness in the FS-29 area ranges from approximately 220 to 300 ft.

The Air Force Center for Engineering and the Environment (AFCEE) issued a Record of Decision in 2000 which specified design and construction of a treatment system to address the FS-29 plume (AFCEE 2000). Due to very low concentrations of the FS-29 COCs, no active treatment was needed for the portion of the plume located hydraulically downgradient (i.e., west) of the two extraction wells. An Explanation of Significant Differences for FS-29 was issued in September 2008 to document the final design of the treatment system which included the natural attenuation of the leading edge of the plume as part of the final remedy (AFCEE 2008b); this portion of the plume has since attenuated to concentrations below the MMCL/MCLs and is no longer depicted on the supporting figures.

The FS-29 remedial system consists of two extraction wells (80EW0001 and 80EW0002) and is part of the Southwest Plumes remedial system (Figure L-1). This system was designed to collectively remediate the Chemical Spill-4 (CS-4), CS-20, CS-21, and FS-29 groundwater plumes. The contaminated groundwater is captured by extraction wells in each plume and treated in a centrally located treatment plant, the Hunter Avenue Treatment Facility (HATF). The flow from the CS-4 and CS-20 extraction wells is combined, enters the HATF through a common influent line, and is treated through a series of granular activated carbon vessels. Likewise, the flow from the CS-21 (and formerly from the FS-29 extraction wells when the FS-29 wells were operational prior to September 2010) enters the HATF through a common influent line; this water is treated through a second granular activated carbon treatment train. The treated water from the CS-4/CS-20 and CS-21 treatment trains exits the HATF in a combined effluent line and all treated water is returned to the aquifer through reinjection wells, an infiltration trench, and an infiltration gallery (AFCEE 2011).

The FS-29 remedial system began operation in September 2006 at a design flow rate of 525 gallons per minute (AFCEE 2008c). An optimization evaluation of the FS-29 treatment system was completed in April 2009, resulting in the shutdown of FS-29 extraction well 80EW0002 on 16 April 2009 (AFCEE 2009). The second FS-29 extraction well (80EW0001) was shut down on 20 September 2010 as a result of further optimization (AFCEE 2010). Therefore, no active treatment is currently being conducted at FS-29. The two FS-29 extraction wells will remain off on an interim basis while long term monitoring (LTM) of the plume is conducted. Monitoring data will continue to be collected and evaluated (which could result in the FS-29 extraction wells returning to operation) until such time that AFCEE and the regulatory agencies agree that the FS-29 remedy can change to LTM.

L1.2 STEP 1: CLEAN WATER LENS

As established in Section 4.1.1 and depicted graphically in Figure 4-1 of the main document, the first step in evaluating the possibility of VI for a groundwater plume is determining whether a continuous 3-ft-thick clean water lens is present above the entire plume and is expected to remain for the foreseeable future as long as the plume exists. If so, it can be concluded that the VI pathway is incomplete and no further evaluation is required.

The clean water lens evaluation included a review of the analytical data for the primary FS-29 COC (EDB), as well as other plume-related volatile organic compounds (VOCs) included in the list of VI contaminants of potential concern in Table 4-1 of the main document. For this FS-29 VI evaluation, the absence of plume-related VOC detections in groundwater in the portion of the aquifer above the plume footprint will define the presence of clean water. The locations of all the monitoring points used for this VI evaluation are shown on Figure L-2. The most recent EDB data used to support this evaluation, and to illustrate the location of the plume in the aquifer, are shown on the southwest-northeast cross-sectional depiction of the FS-29 plume on Figure L-3, and the analytical data are summarized in Table L-1. The well construction and sampling location information used in this evaluation is included in Table L-2.

As described in the conceptual site model (CSM) in Section L1.1, the most recent monitoring data indicate that the FS-29 plume is located deep in the aquifer. In addition, historic characterization data collected during the Remedial Investigation (AFCEE 1999) and the pre-remedial system design investigation (AFCEE 2003), as well as recent data collected under the System Performance and Ecological Impact Monitoring (SPEIM) program, confirm that the FS-29 plume is overlain by a substantial thickness of clean water well in excess of 3 ft. The data that support this aspect of the CSM are as follows and are presented on Figure L-2, Figure L-3, and in Table L-1:

- Groundwater vertical profile data collected in 2009 at sample elevations above the FS-29 plume during rotosonic drilling at 80MW0015A indicate the presence of at least a 60 ft thickness of clean water above the FS-29 plume. This location is near the formerly operating FS-29 extraction wells. In addition, data collected at monitoring wells 80MW0015C and 80MW0013B between 2009 and 2011 further support the presence of a clean water lens above the FS-29 plume. It is noted that 80MW0015A is now located outside of the 2010 plume boundary; however, when installed in 2009, the leading edge of the FS-29 plume was present in this area.

- Groundwater vertical profile data collected at sample elevations above the FS-29 plume during rotosonic drilling at 80MW0001A, 80MW0002A, 80MW0004A, 80MW0006A, 80MW0012A, and 80MW0013A in 2001 and 2002 indicate the presence of at least a 40 ft thickness of clean water above the plume at that time. It is noted that 80MW0001A and 80MW0012A are now located outside of the 2010 plume boundary to the east; however, when installed in 2001 and 2002, respectively, the trailing edge of the FS-29 plume was present in this area. Likewise, locations 80MW0004A and 80MW0006A are now located

outside of the 2010 FS-29 plume boundary but were within the plume footprint at the time of installation and provide useful information to support the presence of a clean water lens.

- Similarly, vertical profile data collected at 69MW1522A, 69MW1536A, and 69MW1543 in 1998 indicate the presence of at least a 10 ft thickness of clean water above the plume at that time. Two of these sample locations are also now located outside of the 2010 plume boundary: 69MW1522A and 69MW1536A are northwest and north of the plume, respectively.

In summary, characterization and monitoring data from multiple locations throughout the area of the FS-29 plume confirm the presence of a clean water lens overlying the entire plume well in excess of the 3-ft thickness criterion used for this VI screening evaluation. It is acknowledged, however, that some of these characterization data are not recent (i.e., dating back to 1998 in some cases). But when combined with more recent data collected in 2009 through 2011 and the overall understanding of the hydrogeologic aspect of the CSM, they still provide sound lines of evidence that the FS-29 plume is located deep in the aquifer and is overlain by a substantial thickness of clean water. Furthermore, given the substantial thickness of clean water above the entire plume and the very low concentrations and limited extent of the plume, a change in the clean water lens presence is not anticipated in the future.

L2.0 CONCLUSIONS AND RECOMMENDATIONS

L2.1 CONCLUSIONS

A review of groundwater characterization and monitoring data collected at FS-29 indicates that a continuous clean water lens at least 3 ft thick is present above the entire body of the FS-29 plume and is expected to be present in the future as long as the plume exists. Therefore, the VI exposure pathway at FS-29 is incomplete, and further evaluation of VI associated with the FS-29 plume is not necessary.

L2.2 RECOMMENDATIONS

No further monitoring or data collection is needed specific to VI. However, as part of the ongoing remedial actions (LTM) at FS-29, AFCEE will continue to monitor the nature and extent of the FS-29 plume under the SPEIM program and will re-evaluate the VI exposure pathway if conditions change such that VI could become a concern.

L3.0 REFERENCES

AFCEE. 2011 (April). *2011 Operations and Maintenance Plan for Groundwater Extraction and Treatment Systems and Wind Turbine*. 404929-O&M-MULTIPLE-OMPLN-001. Prepared by CH2M HILL for AFCEE/MMR, Installation Restoration Program, Otis ANG Base, MA.

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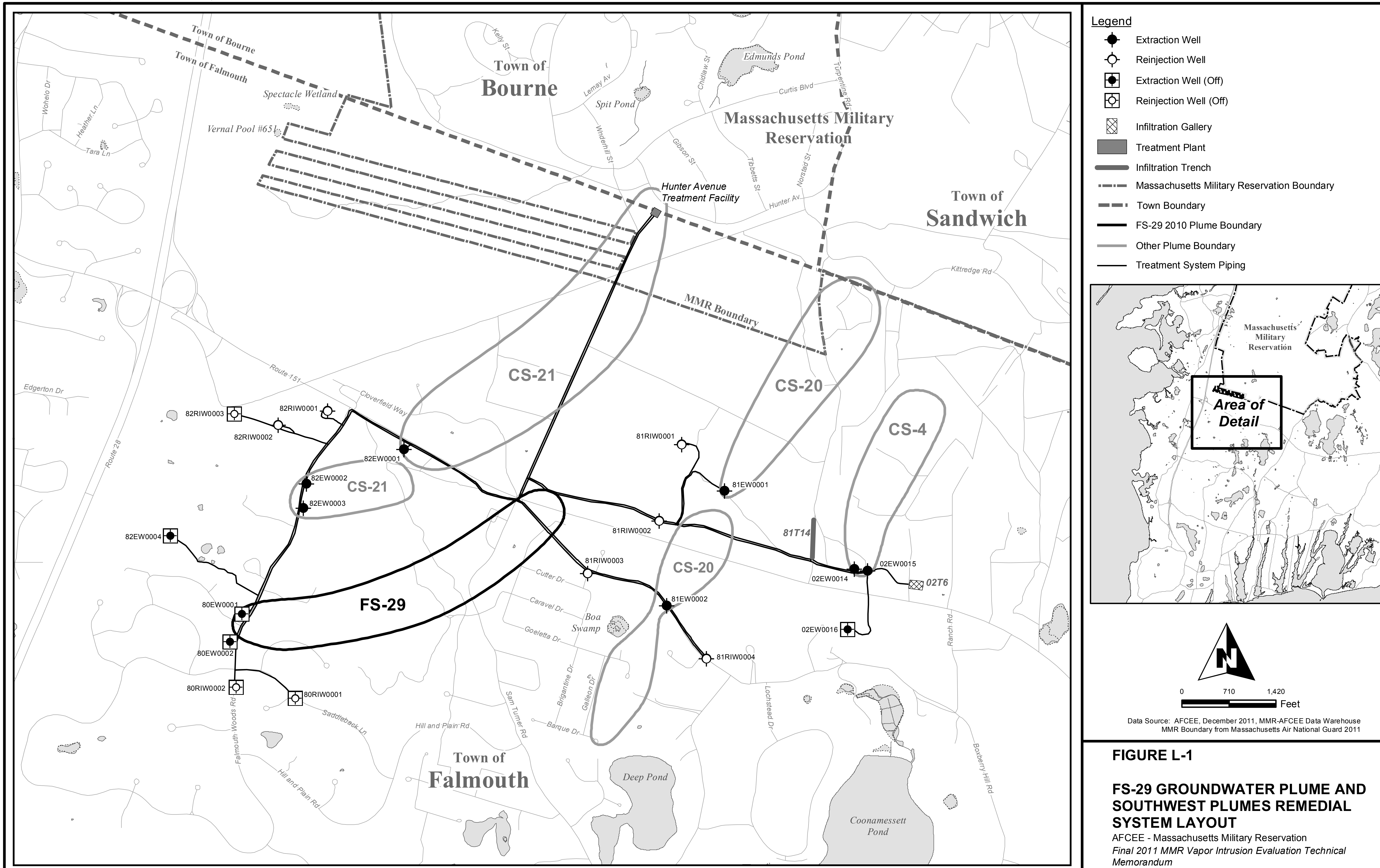

FIGURE L-1

FS-29 GROUNDWATER PLUME AND SOUTHWEST PLUMES REMEDIAL SYSTEM LAYOUT

AFCEE - Massachusetts Military Reservation

Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

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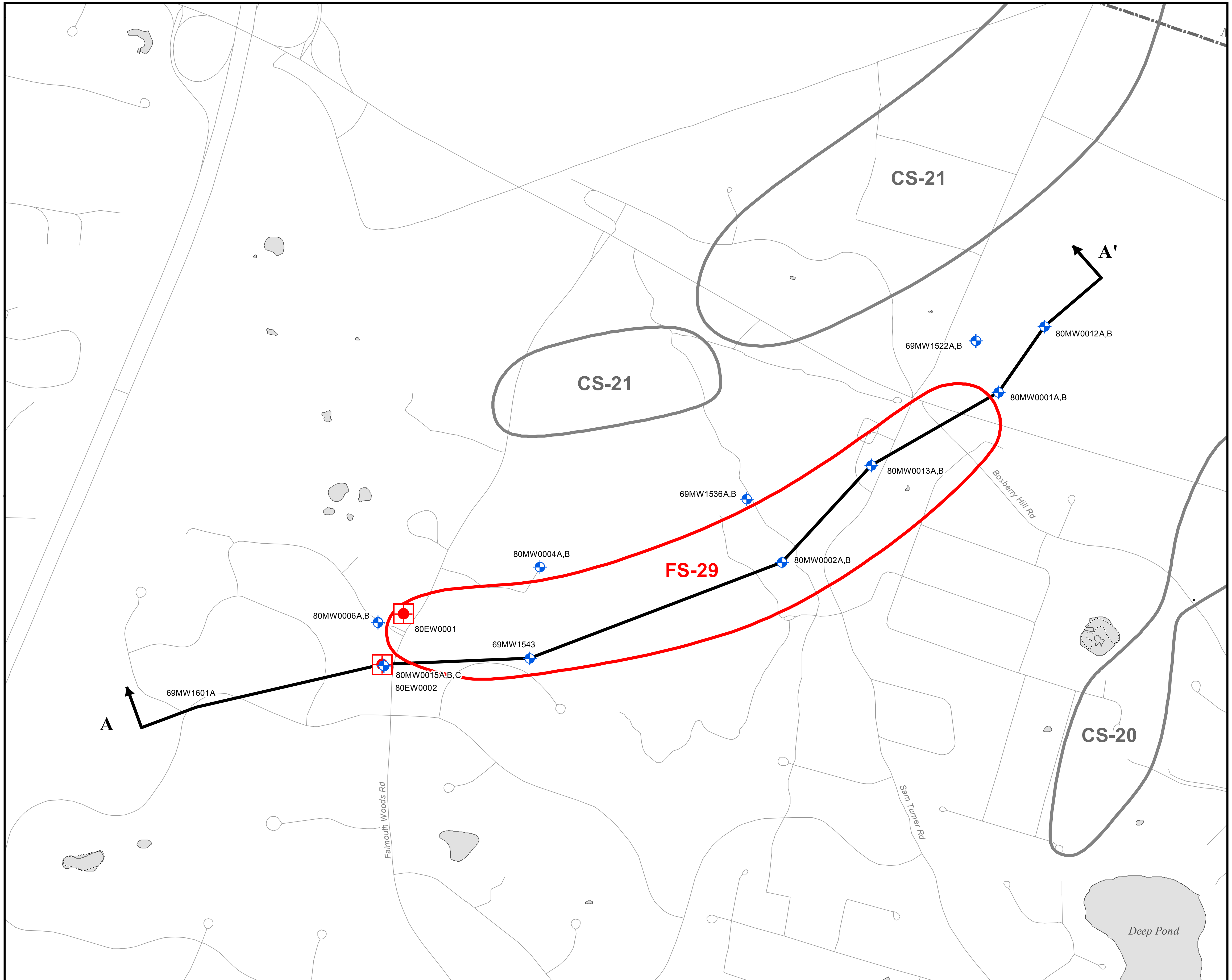
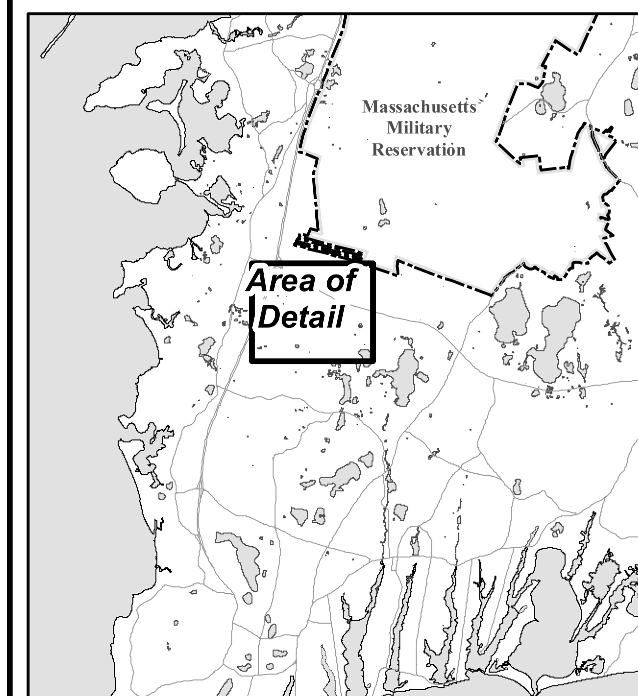


Legend

- Extraction Well (Off)
- Monitoring Well
- Massachusetts Military Reservation Boundary
- FS-29 2010 Plume Boundary
- Other Plume Boundary

Note: The plan view Southwest Plume boundaries will be updated following the 2012 triennial sample event.



0 430 860 Feet

Data Source: AFCEE, December 2011, MMR-AFCEE Data Warehouse
MMR boundary from MA ARNG 2011

FIGURE L-2

FS-29 GROUNDWATER PLUME AND LOCATION OF CROSS-SECTION LINE

AFCEE - Massachusetts Military Reservation

Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

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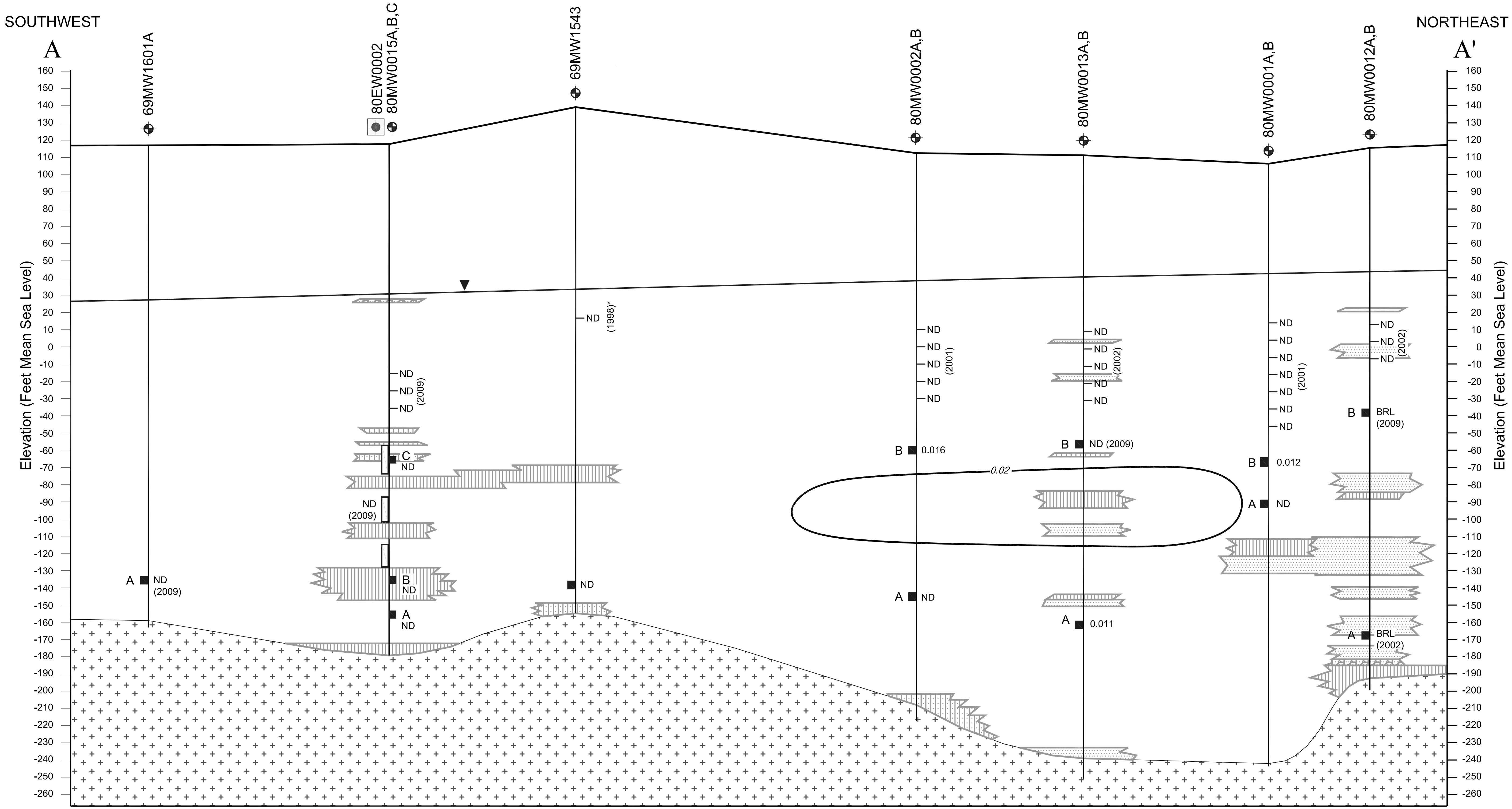

Legend

Monitoring Well	
Extraction Well (Off)	
Water Table (05/2009)	
ND	Nondetect
BRL	Below Reporting Limit
A	Well Screen ID
0.02	EDB Isoconcentration Contour (MMCL = 0.02 µg/L) (Dashed Where Inferred)
0.016	EDB Data (µg/L) Collected in 2011 Unless Otherwise Noted
ND	EDB Vertical Profile Data (µg/L)
	Silt
	Silty Sand
	Gravelly Sand
	Bedrock
	Fine Sand

Data Source: AFCEE, December 2011, MMR-AFCEE Data Warehouse.

Notes:
1) This cross-section presents the most recent (2011 unless otherwise noted) data for FS-29, but does not correspond to the 2010 plume boundary presented on Figure L-2. The plan view Southwest Plume boundaries will be updated following the 2012 triennial sampling event. The depiction of the FS-29 EDB plume shown on this cross-section is based on historic data and the overall understanding of the conceptual site model.
2) *Vertical profile data collected in 1998 (69MW1543) presented in Appendix G of the Final Southwest Operable Unit (SWOU) Remedial Investigation. (AFCEE 1999)
3) Vertical profile data from the shallowest interval have shown to support VI clean water lens evaluation.

V: 60
H: 667
0
Feet

FIGURE L-3

FS-29 CROSS-SECTION A - A'

AFCEE - Massachusetts Military Reservation

Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

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Table L-1
CS-19 Groundwater Data Used in Support of VI Evaluation
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Location	Date Sampled	Mid-Sample Elevation (ft msl)	Sampling Method[1]	Result[2]
69MW1522A	4/2/1998	28.41	VP	No detections of plume-related VI COPCs
69MW1522A	4/2/1998	18.41	VP	No detections of plume-related VI COPCs
69MW1522A	4/2/1998	8.41	VP	No detections of plume-related VI COPCs
69MW1522A	4/2/1998	-1.59	VP	No detections of plume-related VI COPCs
69MW1522A	4/2/1998	-11.59	VP	No detections of plume-related VI COPCs
69MW1522A	4/2/1998	-21.59	VP	No detections of plume-related VI COPCs
69MW1522A	4/2/1998	-31.59	VP	No detections of plume-related VI COPCs
69MW1536A	5/8/1998	22.64	VP	No detections of plume-related VI COPCs
69MW1536A	5/11/1998	12.64	VP	No detections of plume-related VI COPCs
69MW1543	6/23/1998	16.70	VP	No detections of plume-related VI COPCs
80MW0001A	5/4/2001	13.84	VP	No detections of plume-related VI COPCs
80MW0001A	5/4/2001	3.84	VP	No detections of plume-related VI COPCs
80MW0001A	5/4/2001	-6.16	VP	No detections of plume-related VI COPCs
80MW0001A	5/4/2001	-16.16	VP	No detections of plume-related VI COPCs
80MW0001A	5/4/2001	-26.16	VP	No detections of plume-related VI COPCs
80MW0001A	5/4/2001	-36.16	VP	No detections of plume-related VI COPCs
80MW0001A	5/5/2001	-46.16	VP	No detections of plume-related VI COPCs
80MW0002A	1/11/2001	9.98	VP	No detections of plume-related VI COPCs
80MW0002A	1/11/2001	-0.02	VP	No detections of plume-related VI COPCs
80MW0002A	1/11/2001	-10.02	VP	No detections of plume-related VI COPCs
80MW0002A	1/12/2001	-20.02	VP	No detections of plume-related VI COPCs
80MW0002A	1/12/2001	-30.02	VP	No detections of plume-related VI COPCs
80MW0004A	4/24/2001	3.41	VP	No detections of plume-related VI COPCs
80MW0004A	4/24/2001	-6.59	VP	No detections of plume-related VI COPCs
80MW0004A	4/24/2001	-16.59	VP	No detections of plume-related VI COPCs
80MW0004A	4/24/2001	-26.59	VP	No detections of plume-related VI COPCs
80MW0006A	1/31/2001	-15.69	VP	No detections of plume-related VI COPCs
80MW0006A	2/1/2001	-25.69	VP	No detections of plume-related VI COPCs
80MW0006A	2/1/2001	-35.69	VP	No detections of plume-related VI COPCs
80MW0006A	2/1/2001	-45.69	VP	No detections of plume-related VI COPCs
80MW0006A	2/1/2001	-55.69	VP	No detections of plume-related VI COPCs
80MW0006A	2/1/2001	-65.69	VP	No detections of plume-related VI COPCs
80MW0006A	2/1/2001	-75.69	VP	No detections of plume-related VI COPCs
80MW0006A	2/2/2001	-85.69	VP	No detections of plume-related VI COPCs
80MW0006A	2/2/2001	-95.69	VP	No detections of plume-related VI COPCs
80MW0012A	3/19/2002	13.00	VP	No detections of plume-related VI COPCs
80MW0012A	3/19/2002	3.00	VP	No detections of plume-related VI COPCs
80MW0012A	3/20/2002	-7.00	VP	No detections of plume-related VI COPCs
80MW0013A	6/17/2002	8.73	VP	No detections of plume-related VI COPCs
80MW0013A	6/17/2002	-1.27	VP	No detections of plume-related VI COPCs
80MW0013A	6/17/2002	-11.27	VP	No detections of plume-related VI COPCs
80MW0013A	6/17/2002	-21.27	VP	No detections of plume-related VI COPCs
80MW0013A	6/17/2002	-31.27	VP	No detections of plume-related VI COPCs
80MW0013B	5/12/2009	-56.50	MW	No detections of plume-related VI COPCs
80MW0015A	4/20/2009	-15.63	VP	No detections of plume-related VI COPCs

Table L-1
CS-19 Groundwater Data Used in Support of VI Evaluation
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Location	Date Sampled	Mid-Sample Elevation (ft msl)	Sampling Method[1]	Result[2]
80MW0015A	4/20/2009	-25.63	VP	No detections of plume-related VI COPCs
80MW0015A	4/20/2009	-35.63	VP	No detections of plume-related VI COPCs
80MW0015C	5/13/2009	-65.67	MW	No detections of plume-related VI COPCs

Data Source: AFCEE, December 2011, MMR-AFCEE Data Warehouse

Notes:

1. Sample collection method:
   VP = vertical profile groundwater sampling (direct push, rotosonic, or screened hollow-stem auger drilling methods).
   MW = fixed monitoring well

2. See Table 4-1 of the main document for a complete list of VI COPCs.

The data summarized in this table specifically support the FS-29 clean water lens VI evaluation and typically include the most recent sampling results for each location for the plume-related VI COPCs only. If additional historic sampling data exist, they are available for review in the AFCEE-MMR Data Warehouse.

Vertical profile data presented only includes the relevant sample intervals used to support this FS-29 VI evaluation; if analytical data from deeper sample intervals exist, they are available in the AFCEE MMR Data Warehouse.

Sample only analyzed for ethylene dibromide.

Key:

COPC = contaminant of potential concern

FS-29 = Fuel Spill-29

ft msl = feet mean sea level

VI = vapor intrusion

Table L-2
CS-19 Well Construction and Sample Location Information
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Location	Northing (ft)	Easting (ft)	Surface Elevation (ft msl)	Measuring Point Elevation (ft msl)	Total Well Depth (ft bgs)	Top Screen Depth (ft bgs)	Bottom Screen Depth (ft bgs)	Top Screen Elevation (ft msl)	Bottom Screen Elevation (ft msl)	Screen Length (ft)
69MW1522A	233625	850516	103.01	105.52	325	322.31	327.31	-216.79	-221.79	5
69MW1536A	232334	848646	107.64	110.33	279	276.19	281.19	-165.86	-170.86	5
69MW1543	231035	846877	139.20	141.47	280	275.00	280.00	-135.80	-140.8	5
80MW0001A	233205	850702	106.34	105.91	201	195.04	200.14	-88.70	-93.8	5
80MW0002A	231817	848935	112.48	114.48	260	255.00	260.00	-142.52	-147.52	5
80MW0004A	231778	846962	145.91	148.06	288	285.20	289.98	-137.14	-141.92	5
80MW0006A	231328	845641	136.81	136.43	265	258.99	264.08	-122.56	-127.65	5
80MW0012A	233742	851075	115.50	115.08	286	280.75	285.52	-165.25	-170.02	5
80MW0013A	232609	849666	111.23	110.71	275	270.23	275.04	-159.00	-163.81	5
80MW0013B	232610	849666	111.23	110.73	171	165.24	170.23	-54.01	-59.00	5
80MW0015A	230975	845688	116.87	116.49	275	270.02	274.74	-153.15	-157.87	5
80MW0015C	230975	845687	116.87	116.48	185	180.45	184.64	-63.58	-67.77	4

Data Source: AFCEE, December 2011, MMR-AFCEE Data Warehouse

Key:
bgs = below ground surface
FS-29 = Fuel Spill-29
ft = feet
msl = mean sea level

APPENDIX M

LF-1 Vapor Intrusion Evaluation

TABLE OF CONTENTS

Figures

Tables

ACRONYMS AND ABBREVIATIONS

AFCEE	Air Force Center for Engineering and the Environment
BBM	Buzzards Bay Moraine
bgs	below ground surface
CCl_4	carbon tetrachloride
COC	contaminant of concern
COPC	contaminant of potential concern
CS-23	Chemical Spill-23
EDB	ethylene dibromide
EPA	U.S. Environmental Protection Agency
ft	foot/feet
gpm	gallons per minute
HATF	Hunter Avenue Treatment Facility
LF-1	Landfill-1
Mn	Manganese
MCL	Maximum Contaminant Level
MMR	Massachusetts Military Reservation
msl	mean sea level
NWOU	Northwest Operable Unit
PCE	tetrachloroethene
PEST	Parameter Estimation
SPEIM	System Performance and Ecological Impact Monitoring

ACRONYMS AND ABBREVIATIONS

TCE	trichloroethene
VC	vinyl chloride
VI	vapor intrusion
VOC	volatile organic compound
μg/L	micrograms per liter
1,1,2,2-TeCA	1,1,2,2-tetrachloroethane
1,4-DCB	1,4-dichlorobenzene

M1.0 LANDFILL-1 VAPOR INTRUSION DATA EVALUATION

M1.1 LF-1 CONCEPTUAL SITE MODEL

The Landfill-1 (LF-1) groundwater plume is a large dilute dissolved-phase groundwater plume located near the southwest corner of the Massachusetts Military Reservation (MMR) which extends off-base into the towns of Bourne and Falmouth (Figure 1-2 of main document). The source of the LF-1 groundwater plume (Figure M-1) is the former base landfill that was closed in 1995. Three cells of the landfill were capped at that time and three older cells, known as the Northwest Operable Unit, were left uncapped.

The contaminants of concern (COCs) for the LF-1 plume include tetrachloroethene (PCE), trichloroethene (TCE), carbon tetrachloride **(**CCl_4), ethylene dibromide (EDB), 1,1,2,2-tetrachloroethane (1,1,2,2-TeCA), 1,4-dichlorobenzene (1,4-DCB), vinyl chloride (VC), and manganese (Mn). The LF-1 plume boundary is currently defined as the extent of groundwater containing PCE or TCE at concentrations exceeding their Maximum Contaminant Level (MCL) of 5 micrograms per liter (µg/L). The distribution of concentrations exceeding the applicable standards for the remaining seven LF-1 COCs (included in Table 1-3 of the main document) is contained within the area of the composite TCE/PCE plume boundary. The LF-1 plume is comprised of three chemically distinct areas referred to as the northern plume lobe, the central plume lobe, and the southern plume lobe (Figure M-1). The northern plume lobe is predominantly comprised of TCE with a minor component of 1,1,2,2-TeCA; the central plume lobe is predominantly comprised of PCE; and the southern plume lobe is comprised of a mixture of PCE, TCE, CCl_4, and VC. EDB, 1,4-DCB, and Mn are less prevalent COCs that are detected in limited areas within the southern plume lobe.

The LF-1 source area is located in the southern portion of the MMR and is bounded by Turpentine Road to the east, Frank Perkins Road to the west, Herbert Road to the north, and Connery Avenue to the south (Figure M-1). The landfill occupies approximately 100 acres of open to heavily wooded terrain and began operation in 1941 as the primary solid waste disposal facility at MMR. From the 1940s until 1984, unregulated disposal activities were conducted at the site; from 1984 to 1993, regulated disposal activities were conducted by the National Guard

Bureau at the LF-1 landfill as a component of the MMR Hazardous Waste Management Plan (AFCEE 2008). Closure activities at the unlined LF-1 landfill included capping the three most recently used cells and instituting post-closure monitoring for these cells in December 1995. The LF-1 landfill cover system includes an associated surface water drainage system and 70 vents designed to release gas from the interior of the landfill and vapor probe monitoring points. The primary purpose of the landfill cover and associated drainage structures is to minimize the amount of precipitation that infiltrates the landfill and produces leachate (water containing contaminants, nutrients, and microorganisms) that could act as an ongoing source of contamination to the groundwater plume (AFCEE 2011a).

Based on the most recent depiction of the LF-1 plume boundary, the plume is approximately 3.5 miles long, extending from the landfill source area to the west-southwest where the uncaptured portions of the northern and southern lobes of the plume rise in the aquifer to discharge to Red Brook Harbor and Squeteague Harbor, respectively (Figures M-1). A plan view of the LF-1 plume along with the location of the cross-section lines and the monitoring locations used to support this vapor intrusion (VI) evaluation are shown in Figure M-2. Cross-sectional views of the LF-1 northern and southern lobes are provided as Figure M-3 (TCE) and Figure M-4 (PCE), respectively. The LF-1 plume has a maximum width of approximately 4,000 feet (ft) and a maximum thickness of approximately 90 ft. Characteristic of many of the MMR groundwater plumes, the LF-1 plume descended in the aquifer as it migrated from its source area due to recharge accretion which has resulted in the majority of the plume being located relatively deep in the aquifer and overlain by a lens of clean groundwater. The LF-1 northern plume lobe is up to approximately 50 ft thick in the aquifer and the upper boundary of the plume is between approximately 120 and 210 ft below ground surface (bgs) and between 70 and 140 ft below the water table (Figure M-3). The LF-1 southern/central plume lobe is up to approximately 90 ft thick in the aquifer and the upper boundary of the plume is between approximately 70 and 250 ft bgs and between 50 and 140 ft below the water table (Figure M-4).

The topography of the land at the far eastern and western portions of the LF-1 plume can be characterized as broad, flat, and gently sloping glacial outwash plains. However, in the central portion of the LF-1 plume, near the extraction well fence, the plume travels through and beneath

the Buzzards Bay Moraine (BBM), which is a hummocky north-south trending ridge of glacial deposits. Within the footprint of the plume, the maximum and minimum ground surface elevations are 259 ft mean sea level (msl) and 0 ft msl, respectively (AFCEE 2011a).

Flow within the aquifer is predominantly horizontal, and in the LF-1 area is mainly to the west towards Buzzards Bay (Figure 1-1 of main document). The depth to groundwater in the vicinity of the LF-1 plume ranges from less than a few ft near Red Brook and Squeteague harbors to approximately 190 ft bgs below the top of the BBM (i.e., the highest ground surface elevation). The elevation of the water table is approximately 65 ft msl below the source area and near 0 ft msl in the downgradient portion of the plume near Red Brook and Squeteague harbors. The aquifer saturated thickness in the LF-1 area varies from 140 to 220 ft. Most of the LF-1 plume is overlain by a substantial thickness of clean water that is up to 140 ft thick; however, the thickness of the clean water lens lessens in several portions of the plume (AFCEE 2011a). This is discussed in detail in the next section.

The interim remedial design for LF-1 consisted of five extraction wells located along the MMR western boundary that began operation on 26 August 1999. In 2007, the Air Force Center for Engineering and the Environment (AFCEE) issued a Record of Decision (AFCEE 2007) which specified continued active treatment of the LF-1 plume with the existing remedial system and expansion of the system to improve capture of the southern plume lobe at the base boundary. The expansion was implemented in 2006 and included the addition of one extraction well for the LF-1 plume and two extraction wells for the adjacent Chemical Spill-23 (CS-23) plume.

The ongoing remedial actions at LF-1 are managed under the System Performance and Ecological Impact Monitoring (SPEIM) program. The close proximity of the LF-1 and CS-23 plumes (Figure M-1) and remedial systems warrant that the LF-1 and CS-23 SPEIM programs be combined. Therefore, data collection, data assessment, groundwater modeling, and reporting are performed jointly under a combined LF-1/CS-23 SPEIM program. The LF-1/CS-23 remedial system is comprised of six LF-1 extraction wells, one LF-1 reinjection well, two CS-23 extraction wells, two LF-1/CS-23 infiltration trenches, and two water treatment plants. The extraction wells are aligned in a roughly north-south orientation parallel with the MMR western base boundary (Figure M-1).

The expanded LF-1/CS-23 remedial system became operational on 05 December 2006 with 595 gallons per minute (gpm) being treated at the LF-1 treatment plant and 1,350 gpm being treated through the LF-1/CS-23 treatment trains at the Hunter Avenue Treatment Facility (HATF). At a Technical Update meeting on 16 March 2011, AFCEE presented a Parameter Estimation (PEST) modeling approach to optimize the LF-1/CS-23 treatment systems which was verbally approved by the regulators at the meeting (based on AFCEE's understanding and meeting notes). AFCEE implemented the revised flow rates on 16 March 2011, which included a reduction in flow rates from 595 gpm to 525 gpm at LF-1 and from 1,350 gpm to 1,071 gpm at HATF LFl-1/CS-23. During an optimization discussion meeting with the U.S. Environmental Protection Agency (EPA) and Massachusetts Department of Environmental Protection on 28 June 2012, EPA requested AFCEE return the LF-1/CS-23 flow rates to the pre-PEST optimization scenario to allow time for further review of the PEST modeling approach. AFCEE returned the LF-1/CS-23 flow rates to pre-PEST conditions. The LF-1 remedial system was designed to capture the portions of the northern and southern/central plume lobes that were hydraulically upgradient (i.e., east) of the LF-1 treatment system at the time of system startup thus preventing further migration of the on-base portion of the plume to the west (AFCEE 2007). It was agreed that the portions of the LF-1 plume that were hydraulically downgradient (i.e., west) of the LF-1 treatment system at the time of system startup (in 1999) would naturally attenuate. The most recent transport modeling simulations predict that the LF-1 extraction wells can be turned off by approximately 2055. TCE and/or PCE concentrations in the portion of the LF-1 plume located to the east of the base boundary are expected to decline below the MCL through natural attenuation sometime after 2060 (AFCEE 2012).

M1.2 STEP 1: CLEAN WATER LENS

As established in Section 4.0 and depicted graphically in Figure 4-1 of the main document, the first step in evaluating the possibility of VI for a groundwater plume is determining whether a continuous 3-ft-thick clean water lens is present above the entire plume and is expected to remain for the foreseeable future as long as the plume exists. If the evaluation indicates that a clean water lens is present using the criteria presented in Section 4.1.1 of the main document, it can be concluded that the VI pathway is incomplete and no further evaluation is required.

The clean water lens evaluation included a review of the analytical data for the seven volatile LF-1 COCs, as well as other plume-related volatile organic compounds (VOCs) included in the list of VI contaminants of potential concern (COPCs) in Table 4-1 of the main document. For this LF-1 evaluation, the absence of plume-related VOC detections in groundwater in the portion of the aquifer above the plume footprint will define the presence of clean water. The locations of all the monitoring points used for this VI evaluation are shown on Figure M-2. The most recent TCE and PCE data used to support this evaluation are shown on the cross-sectional depictions of the northern and southern lobes of the LF-1 plume on Figures M-3 and M-4, respectively, and all the analytical data are summarized in Table M-1. The well construction and sampling location information used in this evaluation are included in Table M-2.

Characterization data, as detailed further below, indicate that a lens of clean groundwater well in excess of 3 ft exists over the majority of the LF-1 plume. However, the initial inspection of existing data for LF-1 indicated that a clean water lens could not be demonstrated with an adequate degree of certainty in three areas of limited extent; below the LF-1 source area (i.e., landfill); and, at the leading edges of the northern and southern plume lobes where the plume rises in the aquifer and discharges to Red Brook and Squeteague Harbors, respectively (Figures M-2, M-3, and M-4). To address data gaps in these areas, groundwater vertical profile samples were collected in 2011 using the AFCEE direct push rig at locations 27DP0015 through 27DP0019 (Figure M-2). Samples were collected at the water table and approximately 5 ft below the water table to assess whether a clean water lens exists. The data from these locations successfully addressed the data gaps and are incorporated into the discussions in the following subsections. The subsections evaluate the clean water lens at five distinct LF-1 plume areas; the source area, the main body of the northern and southern/central plume lobes east of the base boundary, and the portions of the northern and southern/central plume lobes that are located west of the base boundary.

M1.2.1 LF-1 Source Area

For the purposes of this evaluation the LF-1 source area is defined as the landfill cells and the area immediately downgradient (i.e., south and west) of the landfill (Figures M-1 and M-2). The trailing edge of the LF-1 plume is located below the southern edge of the LF-1 source area

(Figure M-2). Due to the effectiveness of the cap, monitoring data do not indicate the landfill is a significant continuing source of contamination to the LF-1 groundwater plume (AFCEE 2011a). The data that support the clean water lens evaluation for this area are presented in Figures M-2, M-3, and M-4 and Table M-1:

- Groundwater vertical profile data were collected in May 2011 at 27DP0015 to support this VI evaluation. 27DP0015 is located within a BMX bicycle track area, which is south and east of the capped landfill cells. This location was chosen because it is hydraulically downgradient of the post-1970 landfill cell (Figure M-2) and adjacent to the only structures present within the source area footprint. These structures, which are associated with BMX track operations, consist of a registration shed, concession stand, timekeepers stand, and a bike maintenance shed. The data collected at 27DP0015 indicate the presence of a clean water lens below these structures that is at least 8 ft thick (Figure M-4).
- Monitoring data collected at 27MW0015A (2008) indicate that no detectable concentrations of LF-1 related VI COPCs are present on the western edge of the landfill source area.
- Groundwater vertical profile data collected immediately south of the source area along Connery Avenue (27DP0009, 27DP0010, 27DP0011, and 27DP0012) in 2007 and 2008 provide evidence of a clean water lens that is at least 18 ft thick.

M1.2.2 LF-1 Northern Plume Lobe - East of Base Boundary

The upper boundary of the shallower portion of the northern plume lobe located east of the base boundary is between approximately 190 to 210 ft bgs (Figure M-3). Extraction well 27EW0005 hydraulically captures the shallow portion of the northern plume lobe (AFCEE 2009) and has prevented its migration to the west of the base boundary. The data that support the presence of a clean water lens above this portion of the plume are presented in Figures M-2 and M-3 and Table M-1:

- Groundwater vertical profile data collected in 2005 at 27MW1010A provide evidence of a clean water lens that is at least 40 ft thick.
- Groundwater vertical profile data collected in 1998 at 27MW0108A provide evidence of a clean water lens that was at least 50 ft thick at that time. Monitoring data collected at 27MW0108B in 2001, when no plume-related VI COPCs were detected, further support this finding.

M1.2.3 LF-1 Southern/Central Plume Lobe - East of Base Boundary

The upper boundary of the portion of the southern/central lobe located to the east of the base boundary (and remedial system) (Figure M-4) is between approximately 120 and 220 ft bgs. The data that support the presence of a clean water lens for this area are presented in Figures M-2 and M-4, and on Table M-1:

- Groundwater vertical profile data collected in 2006 at 27MW1013A provide evidence of a clean water lens that is at least 45 ft thick.
- Groundwater vertical profile data collected in 2004 at 27MW1004A provide evidence of a clean water lens that is at least 33 ft thick.
- Groundwater vertical profile data collected in 2004 at 27MW1007A provide evidence of a clean water lens that is at least 35 ft thick.
- Monitoring data collected at the following wells screened above the LF-1 plume, in order of most recent to oldest, were used to confirm the presence of a clean water lens in this area: 27MW1004B (2011), 27MW0601C (2008), 27MW0102B (2008), 27MW0107B (2008), and 27MW0601D (1998).

M1.2.4 LF-1 Northern Plume Lobe - West of Base Boundary

The deep uncaptured portion of the LF-1 northern lobe rises in the aquifer as it approaches Red Brook Harbor (Figure M-3). Hydraulically upgradient (i.e., east) of the discharge area, the upper boundary of this uncaptured portion of the plume is located approximately 130 ft bgs (based on monitoring data collected at the USBW493 well cluster). The data that support the clean water lens evaluation for this area are presented in Figures M-2 and M-3 and Table M-1:

- Groundwater vertical profile data collected in 2011 at 27DP0019 indicate the presence of a clean water lens that is at least 8 ft thick. It is noted that 27DP0019 was installed approximately 100 ft east of the shoreline and the data collected at this location suggest that the clean water lens that exists above the LF-1 plume likely extends some distance offshore to the west.
- Monitoring data collected in 2004 from monitoring wells 27MW0568B and C (screened above the LF-1 plume) were used to confirm the presence of a clean water lens in this area.

M1.2.5 LF-1 Southern Plume Lobe - West of Base Boundary

The uncaptured portion of the LF-1 southern lobe rises in the aquifer as it approaches its discharge location in Squeteague Harbor (Figure M-4). Hydraulically upgradient (i.e., east) of the discharge area, the upper boundary of the plume is located approximately 70 ft bgs (based on monitoring data collected at 27MW0064A/B). The data that support the clean water lens evaluation for this area are presented in Figures M-2 and M-4 and Table M-1:

- Groundwater vertical profile data were collected at 27DP0016 (May 2011), 27DP0017 (May 2011), and 27DP0018 (September 2011) indicate the presence of clean water lens at least 8 ft thick in this area. These characterization data indicate that the plume is overlain by a lens of clean water up to, and possibly beyond, the location of the shoreline.
- Monitoring data collected from 27MW0109B (2011) and 27MW0038 (2004) (both screened above the LF-1 plume) were used to confirm the presence of a clean water lens in this area.

M1.2.6 Clean Water Lens Summary

Characterization and monitoring data from multiple locations throughout the five distinct portions of the LF-1 plume confirm the presence of a clean water lens overlying the entire plume well in excess of the 3-ft thickness criterion used for this VI screening evaluation. It is acknowledged, however, that some of these characterization data are not recent (i.e., dating back to 1998 in some cases). But when combined with more recent data (including five direct push borings completed for this evaluation in 2011), and the overall understanding of the hydrogeologic aspect of the conceptual site model, the data still provide sound lines of evidence that the LF-1 plume is overlain by a sufficient thickness of clean water such that VI should not be a concern. Furthermore, given that the uncaptured portions of the plume have reached their discharge points in Red Brook Harbor and Squeteague Harbor, concentrations are generally declining, and remedial actions are ongoing, a change in the clean water lens presence is not anticipated in the future.

M2.0 CONCLUSIONS AND RECOMMENDATIONS

M2.1 CONCLUSIONS

A review of the groundwater characterization and monitoring data collected at LF-1 indicates that a continuous clean water lens at least 3 ft thick is present above the entire body of the LF-1 plume and is expected to be present in the future as long as the plume exists. As evidenced by data indicating the presence of a substantial clean water lens overlying the entire extent of the LF-1 plume, and the ongoing active treatment to control its migration, the VI exposure pathway at LF-1 is incomplete, and further evaluation of VI associated with the LF-1 plume is not necessary.

M2.2 RECOMMENDATIONS

No further monitoring or data collection is needed specific to VI. However, as part of the ongoing remedial actions at LF-1, AFCEE will continue to monitor the nature and extent of the LF-1 plume under the SPEIM program and will re-evaluate the VI exposure pathway if conditions change such that VI could become a concern.

M3.0 REFERENCES

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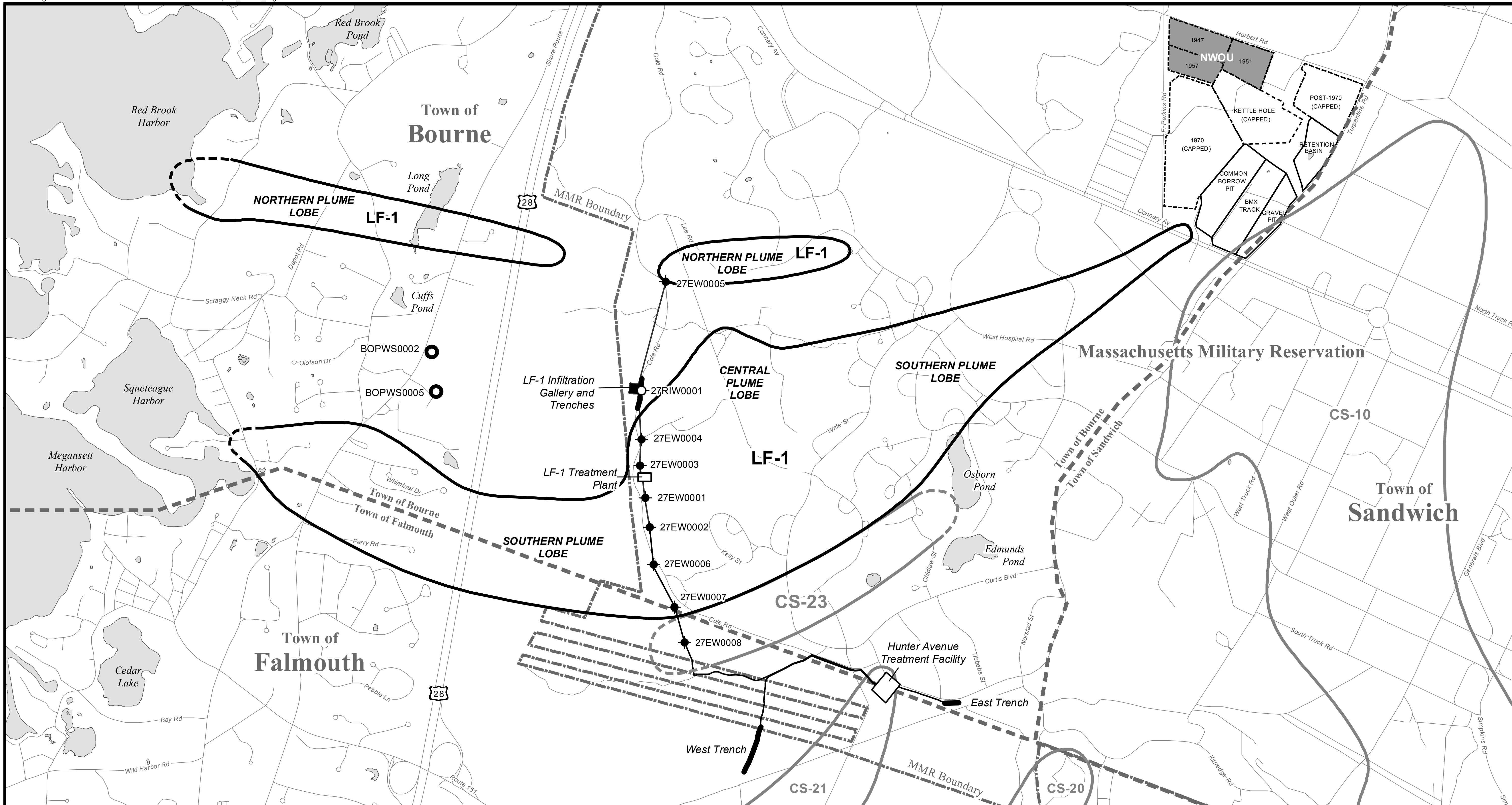

Data Source: AFCEE, January 2012, AFCEE-MMR Data Warehouse
MMR Boundary from MA ARNG 2011

Legend

- Extraction Well
- Reinjection Well
- Bourne Public Water Supply Well
- Treatment Plant
- Northwest Operable Unit (NWOU)
- LF-1/CS-23 Treatment System Pipeline
- Other Landfill Area Boundary
- Landfill Cell Boundary
- Town Boundary
- LF-1 Plume Boundary (Dashed Where Inferred)
- Other Plume Boundary (Dashed Where Inferred)
- Infiltration Trench/Gallery
- Massachusetts Military Reservation Boundary

N

0 850 1,700 Feet

FIGURE M-1

LF-1 GROUNDWATER PLUME AND REMEDIAL SYSTEMS

AFCEE - Massachusetts Military Reservation

Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

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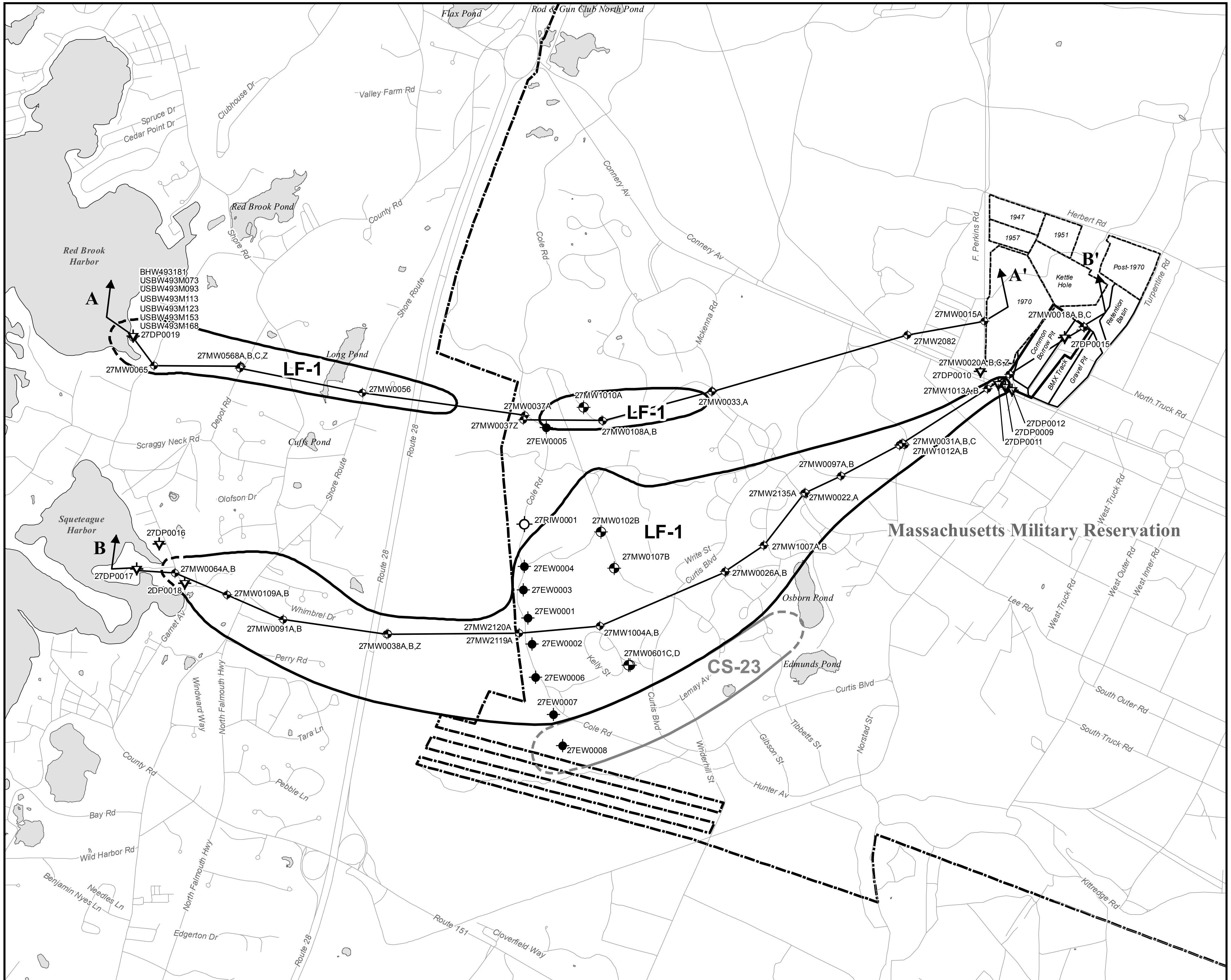

Legend

- Massachusetts Military Reservation Boundary
- LF-1 Plume Boundary (Dashed Where Inferred)
- Other Plume Boundary (Dashed Where Inferred)
- Landfill Cell Boundary
- Other Landfill Area Boundary
- Monitoring Well
- Extraction Well
- Direct Push Location
- Reinjection Well

N

0 950 1,900 Feet

Data Source: AFCEE, January 2012 MMR-AFCEE Data Warehouse
MMR Boundary from Massachusetts Air National Guard 2011

FIGURE M-2

LF-1 GROUNDWATER PLUME AND LOCATION OF CROSS-SECTION LINES

AFCEE - Massachusetts Military Reservation

Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

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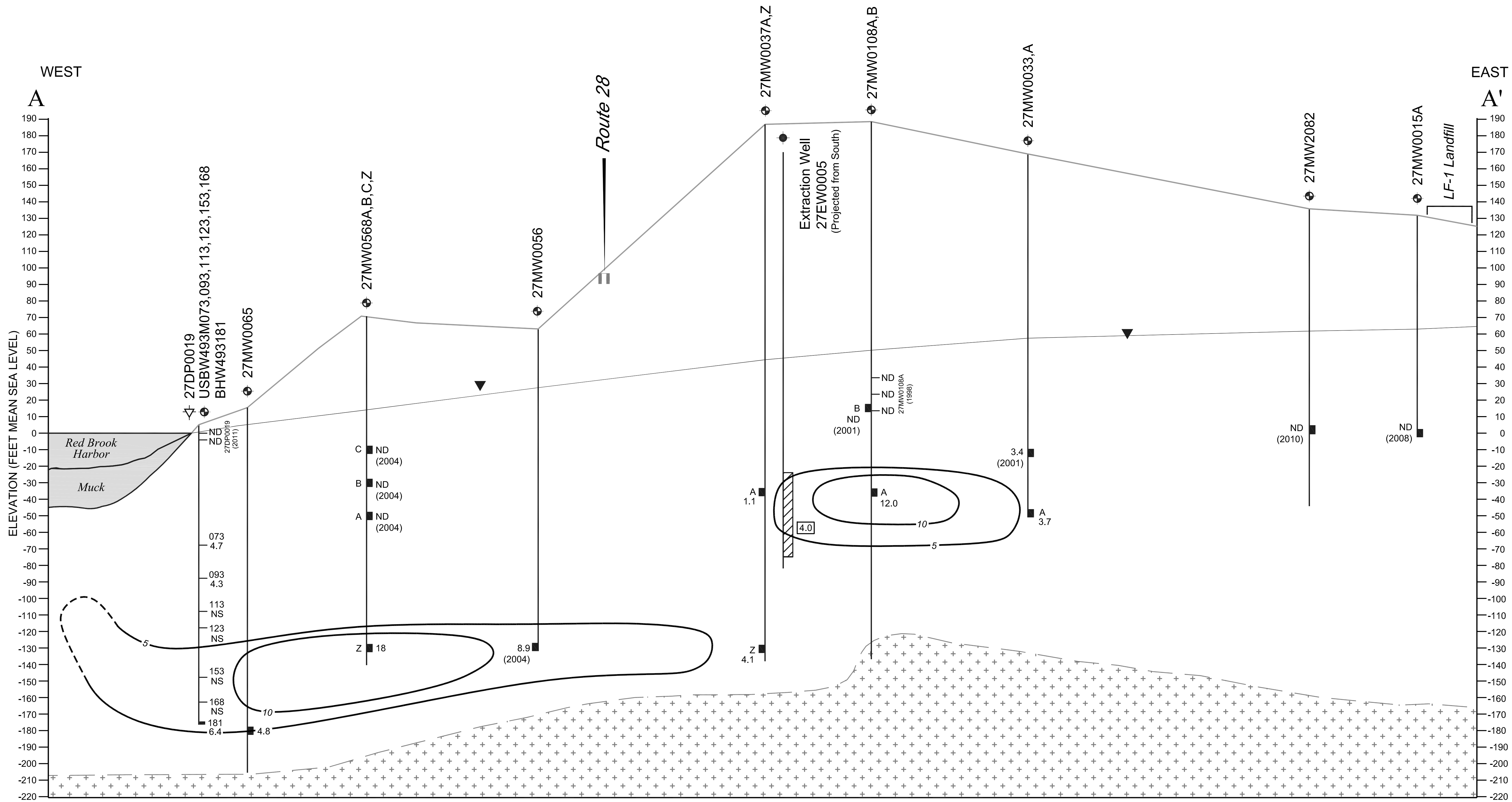

Legend

Monitoring Well	4.4 Most Recent TCE Data (µg/L) at Extraction Well	A Well Screen ID	5 — 2011 TCE Isoconcentration Contour (MCL = 5 µg/L) (Dashed Where Inferred)
Water Table	ND Nondetect	3.7 TCE Data (µg/L) Collected in 2011 Unless Otherwise Noted	Projected Extraction Well Screen
Direct Push Location	NS Not Sampled	ND TCE Vertical Profile Data (µg/L) (Date Collected)	Bedrock

Data Source: AFCEE, January 2012, MMR-AFCEE Data Warehouse

Notes:
1) This cross-section presents the most recent (2011 unless otherwise noted) data for the LF-1 plume.
2) Vertical profile data collected from the shallowest intervals are shown to support this VI clean water lens evaluation.

V: 60
H: 1333
0 Feet

FIGURE M-3

LF-1 CROSS-SECTION A-A' (NORTHERN PLUME LOBE)

AFCEE - Massachusetts Military Reservation

Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

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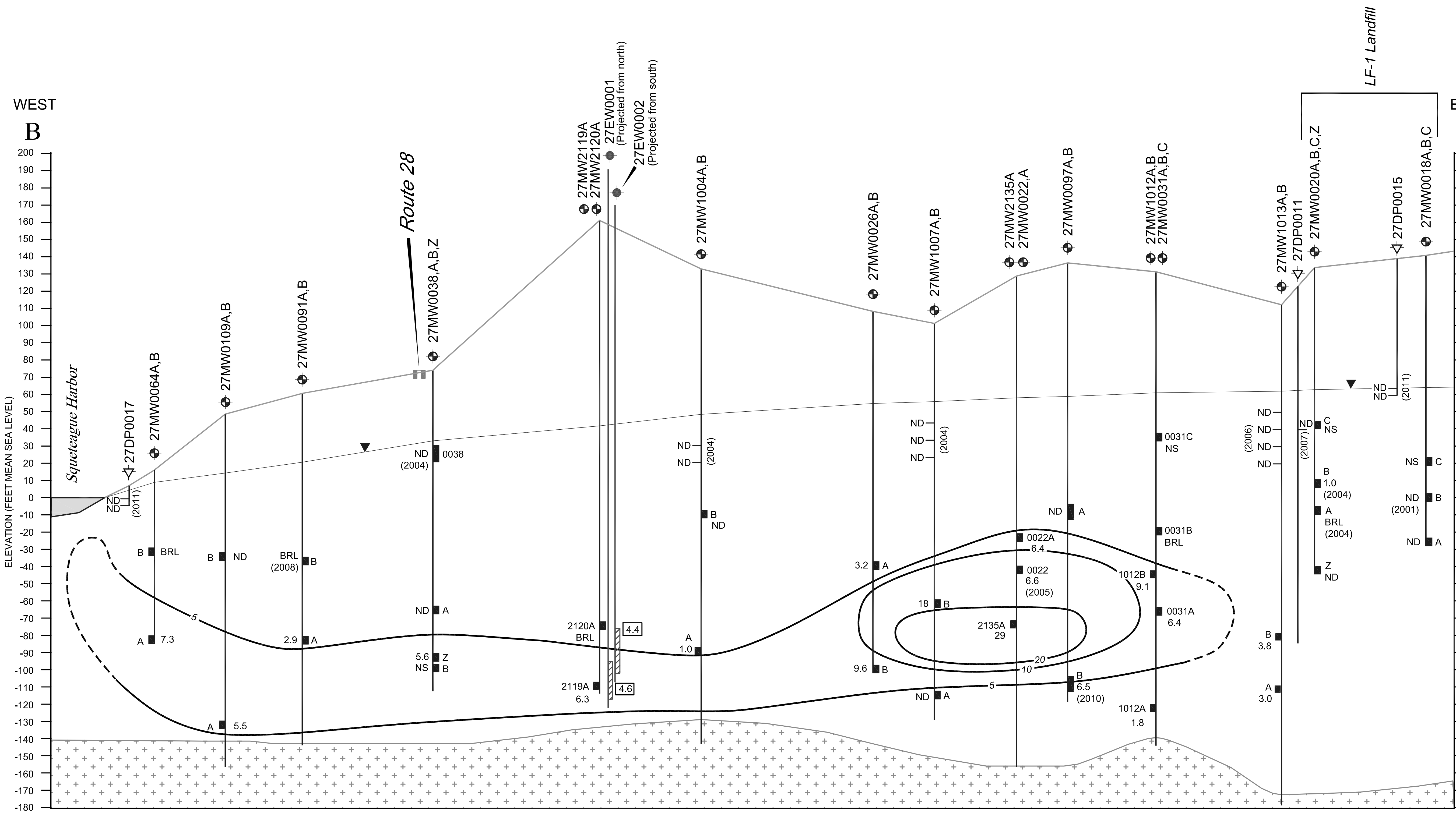

Legend

Monitoring Well	4.4	Most Recent PCE Data (µg/L) at Extraction Well	
Extraction Well	BRL	Below Reporting Limit	
Water Table	ND	Nondetect	
Direct Push Location	NS	Not Sampled	

A — Well Screen ID

3.7 — PCE Data (µg/L) Collected in 2011 Unless Otherwise Noted

ND — PCE Vertical Profile Data (µg/L) (Date Collected)

5 — 2011 PCE Isoconcentration Contour (MCL = 5 µg/L) (Dashed Where Inferred)

Projected Extraction Well Screen

Bedrock

Data Source: AFCEE, January 2012, MMR-AFCEE Data Warehouse

Notes:
1) This cross-section presents the most recent (2011 unless otherwise noted) data for the LF-1 plume.
2) Vertical profile data collected from the shallowest intervals are shown to support this VI clean water lens evaluation.

0 V: 60 H: 1528 Feet

FIGURE M-4

LF-1 CROSS-SECTION B-B' (SOUTHERN/CENTRAL PLUME LOBE)

AFCEE - Massachusetts Military Reservation

Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

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Table M-1
LF-1 Groundwater Data Used in Support of VI Evaluation
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Location	Date Sampled	Mid-Sample Elevation (ft msl)	Sampling Method[1]	Result[2]
27DP0009	6/23/2008	38.5	VP	No detections of plume-related VI COPCs
27DP0010	11/2/2007	60.5	VP	No detections of plume-related VI COPCs
27DP0010	11/2/2007	50.5	VP	No detections of plume-related VI COPCs
27DP0010	11/2/2007	40.5	VP	No detections of plume-related VI COPCs
27DP0011	6/13/2008	39.5	VP	No detections of plume-related VI COPCs
27DP0012	6/27/2008	52.5	VP	No detections of plume-related VI COPCs
27DP0012	6/30/2008	42.5	VP	No detections of plume-related VI COPCs
27DP0015	5/18/2011	63.6	VP	No detections of plume-related VI COPCs
27DP0015	5/18/2011	59.5	VP	No detections of plume-related VI COPCs
27DP0016	5/19/2011	9.5	VP	No detections of plume-related VI COPCs
27DP0016	5/19/2011	5.5	VP	No detections of plume-related VI COPCs
27DP0017	5/26/2011	-0.7	VP	No detections of plume-related VI COPCs
27DP0017	5/26/2011	-4.7	VP	No detections of plume-related VI COPCs
27DP0018	9/14/2011	7.8	VP	No detections of plume-related VI COPCs
27DP0018	9/14/2011	3.3	VP	No detections of plume-related VI COPCs
27DP0019	5/24/2011	0.0	VP	No detections of plume-related VI COPCs
27DP0019	5/24/2011	-4.1	VP	No detections of plume-related VI COPCs
27MW0015A	2/11/2008	0.0	MW	No detections of plume-related VI COPCs
27MW0038	4/19/2004	25.6	MW	No detections of plume-related VI COPCs
27MW0102B	2/6/2008	24.3	MW	No detections of plume-related VI COPCs
27MW0107B	2/6/2008	15.7	MW	No detections of plume-related VI COPCs
27MW0108A	6/10/1998	33.6	VP	No detections of plume-related VI COPCs
27MW0108A	6/10/1998	23.6	VP	No detections of plume-related VI COPCs
27MW0108A	6/10/1998	13.6	VP	No detections of plume-related VI COPCs
27MW0108B	1/5/2001	15.2	MW	No detections of plume-related VI COPCs
27MW0109B	6/6/2011	-34.1	MW	No detections of plume-related VI COPCs
27MW0568B	4/8/2004	-30.1	MW	No detections of plume-related VI COPCs
27MW0568C	4/8/2004	-10.1	MW	No detections of plume-related VI COPCs
27MW0601C	2/15/2008	12.2	MW	No detections of plume-related VI COPCs
27MW0601D	12/3/1998	32.1	MW	No detections of plume-related VI COPCs
27MW1004A	4/28/2004	30.4	VP	No detections of plume-related VI COPCs
27MW1004A	4/28/2004	20.4	VP	No detections of plume-related VI COPCs
27MW1004B	6/2/2011	-9.6	MW	No detections of plume-related VI COPCs
27MW1007A	4/26/2004	43.4	VP	No detections of plume-related VI COPCs
27MW1007A	4/26/2004	33.4	VP	No detections of plume-related VI COPCs
27MW1007A	4/26/2004	23.4	VP	No detections of plume-related VI COPCs
27MW1010A	1/20/2005	19.2	VP	No detections of plume-related VI COPCs
27MW1010A	1/20/2005	9.2	VP	No detections of plume-related VI COPCs

Table M-1
LF-1 Groundwater Data Used in Support of VI Evaluation
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Location	Date Sampled	Mid-Sample Elevation (ft msl)	Sampling Method[1]	Result[2]
27MW1013A	4/12/2006	49.6	VP	No detections of plume-related VI COPCs
27MW1013A	4/12/2006	39.6	VP	No detections of plume-related VI COPCs
27MW1013A	4/12/2006	29.6	VP	No detections of plume-related VI COPCs
27MW1013A	4/12/2006	19.6	VP	No detections of plume-related VI COPCs

Data Source: AFCEE, December 2011, MMR-AFCEE Data Warehouse

Notes:

1. Sample collection method:
   VP = vertical profile groundwater sampling (direct push, rotosonic, or screened hollow-stem auger drilling methods)
   MW = fixed monitoring well
2. See Table 4-1 of the main document for a complete list of VI COPCs.

The data summarized in this table specifically support the LF-1 clean water lens VI evaluation and typically include the most recent sampling results for each location for the plume-related VI COPCs only. If additional historic sampling data exist, they are available for review in the AFCEE-MMR Data Warehouse.

Vertical profile data presented only include the relevant sample intervals used to support this LF-1 VI evaluation; if analytical data from deeper sample intervals exist, they are available in the AFCEE MMR Data Warehouse.

Key:

COPC = contaminant of potential concern
LF-1 = Landfill-1
ft msl = feet mean sea level
VI = vapor intrusion

Table M-2
LF-1 Well Construction and Sample Location Information
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Location	Northing (ft)	Easting (ft)	Surface Elevation (ft msl)	Measuring Point Elevation (ft msl)	Total Well Depth (ft bgs)	Top Screen Depth (ft bgs)	Bottom Screen Depth (ft bgs)	Top Screen Elevation (ft msl)	Bottom Screen Elevation (ft msl)	Screen Length (ft)
27DP0009	244858	857027	126	NA	NA	NA	NA	NA	NA	NA
27DP0010	245144	856564	118	NA	NA	NA	NA	NA	NA	NA
27DP0011	244907	856897	122	NA	NA	NA	NA	NA	NA	NA
27DP0012	244795	857151	130	NA	NA	NA	NA	NA	NA	NA
27DP0015	245775	858131	139	NA	NA	NA	NA	NA	NA	NA
27DP0016	241946	841315	14	NA	NA	NA	NA	NA	NA	NA
27DP0017	241478	840901	7	NA	NA	NA	NA	NA	NA	NA
27DP0018	241211	841791	15	NA	NA	NA	NA	NA	NA	NA
27DP0019	245805	840838	3	NA	NA	NA	NA	NA	NA	NA
27MW0015A	246110	856640	132	134.87	134	129.40	134.40	2.50	-2.50	5
27MW0038	240292	845537	74	76.58	54	43.50	53.50	30.58	20.58	10
27MW0102B	242200	849517	237	239.28	215	210.00	215.00	26.81	21.81	5
27MW0107B	241526	849769	198	200.76	185	180.00	185.00	18.21	13.21	5
27MW0108A	244263	849536	189	188.20	227	222.00	227.00	-33.43	-38.43	5
27MW0108B	244262	849553	190	189.27	178	172.00	177.00	17.73	12.73	5
27MW0109B	241021	842578	48	48.11	85	80.00	85.00	-31.60	-36.60	5
27MW0568B	245259	842827	71	73.31	104	98.20	103.20	-27.57	-32.57	5
27MW0568C	245251	842822	71	73.39	84	78.20	83.20	-7.57	-12.57	5
27MW0601C	239729	850063	141	144.36	135	129.90	135.00	11.52	6.42	5
27MW0601D	239722	850036	144	146.42	115	110.00	115.00	33.66	28.66	5
27MW1004A	240443	849501	133	132.60	225	219.76	224.60	-86.83	-91.67	5
27MW1004B	240443	849501	133	132.59	145	140.11	144.98	-7.18	-12.05	5
27MW1007A	241944	852548	101	100.20	218	213.10	218.10	-112.22	-117.22	5
27MW1010A	244512	849194	162	161.30	217	211.68	216.68	-49.98	-54.98	5
27MW1013A	244850	856692	112	111.70	226	221.28	225.52	-109.15	-113.39	4

Data Source: AFCEE, December 2011, MMR-AFCEE Data Warehouse

Key:
bgs = below ground surface
ft = feet
LF-1 = Landfill-1
msl = mean sea level
NA = data not available; locations are direct push vertical profile locations and have no screen information.

APPENDIX N

SD-5 Vapor Intrusion Evaluation

TABLE OF CONTENTS

Figures

Tables

ACRONYMS AND ABBREVIATIONS

AFCEE	Air Force Center for Engineering and the Environment
ANG	Air National Guard
AOC	area of concern
COC	contaminant of concern
COPC	contaminant of potential concern
CSM	conceptual site model
ETR	extraction, treatment, and reinjection
FS	Fuel Spill
ft	feet/foot
FTA-2	Fire Training Area-2
gpm	gallons per minute
LF-2	Landfill-2
LTM	long term monitoring
MCL	Maximum Contaminant Level
MMR	Massachusetts Military Reservation
msl	mean sea level
NDIL	Non-Destructive Inspection Laboratory
PCE	tetrachloroethene
PFSA	Petroleum Fuel Storage Area
SD-5N	Storm Drain-5 North
SD-5S	Storm Drain-5 South
SVE	soil vapor extraction

ACRONYMS AND ABBREVIATIONS

TCE	trichloroethene
VI	vapor intrusion
VOC	volatile organic compound
µg/L	micrograms per liter

N1.0 STORM DRAIN-5 VAPOR INTRUSION EVALUATION

N1.1 SD-5 PLUME CONCEPTUAL SITE MODEL

The Storm Drain-5 (SD-5) groundwater plume was a dilute dissolved-phase groundwater plume which was located in the southeast corner of the Massachusetts Military Reservation (MMR). The SD-5 plume extended from the source area on-base and off-base beneath open space and residential neighborhoods in the area to the north of, and in between, Ashumet Pond and Johns Pond in Mashpee, Massachusetts (Figure N-1 and Figure 1-2 of the main document). The SD-5 plume was defined as the extent of groundwater containing the contaminant of concern (COC) trichloroethene (TCE) at concentrations greater than the Maximum Contaminant Level (MCL) of 5 micrograms per liter (µg/L). Tetrachloroethene (PCE) detections were also common at SD-5, but PCE is not a groundwater COC (AFCEE 2006).

The source area for the SD-5 plume, referred to as the Fuel Spill-5 (FS-5)/SD-5 area of concern (AOC), is located on the MMR in the area between East Truck Road, Richardson Road, Branshaw Street, and Lingley Avenue (Figure N-1). The source of the SD-5 plume was the result of releases from a leaching well at the Non-Destructive Inspection Laboratory (NDIL), a Corrosion Control Shop, and sumps in two nearby aircraft hangers (Hangars 3122 and 3192) that no longer exist and are therefore not shown on supporting figures (ANG 1994).

Source area remedial actions including the demolition of buildings/hangers and removal of leaching wells and drainage structures were conducted between 1990 and 2003. The Air National Guard (ANG) removed approximately 700 gallons of contaminated fluid from an NDIL leaching well in 1990 and the NDIL leaching well was removed in 1996. This removal action was completed as part of the MMR drainage structure removal program and also included the removal of four other drainage structures at SD-5/FS-5 in 1996 (AFCEE 2006). Excavation of contaminated soils at the SD-5 source area began in April 2001. Approximately 6,500 tons of soil were removed and taken off-site for disposal at a state-permitted landfill. In August 2002, a soil-vapor extraction (SVE) system was installed at the site to remediate volatile organic compounds (VOCs) in the subsurface. The SVE system removed approximately 5 pounds of VOCs and was shut down in March 2003 with concurrence from the regulatory agencies

(AFCEE 2006). The SD-5 source area groundwater is currently characterized by the presence of residual dissolved-phase TCE and PCE, and monitoring data confirm that the SD-5/FS-5 AOC is not acting as a continuing source of groundwater contamination (AFCEE 2002).

As shown on Figure N-1, SD-5 is split into two areas, SD-5 North (SD-5N) which is located on-base and SD-5 South (SD-5S) which is located off-base. In August 1997, the Air Force Center for Engineering and the Environment (AFCEE) began operation of an extraction, treatment, and reinjection (ETR) system to address the groundwater contamination at SD-5N. It consisted of a fence of 10 extraction wells, a groundwater treatment plant and eight reinjection wells located at the base boundary (Figure N-1). The ETR system started operation in August 1997 at a flow rate of 355 gallons per minute (gpm). Between 1999 and 2003, the SD-5N system was optimized with the progressive shutdown of extraction wells and reduction in flow due to the success of the remedial actions. In September 2003, AFCEE, with concurrence from the regulatory agencies, shut down the final SD-5N extraction well (28EW0004) which was operating at 55 gpm. The SD-5N reinjection wells continue to be used to return treated groundwater from the Chemical Spill-10 plume to the aquifer (AFCEE 2012). In June 1999, AFCEE began operation of two recirculating wells in SD-5S at a combined flow rate of 120 gpm. In January 2000, AFCEE installed an extraction well that operated at 100 gpm to capture additional contamination at SD5S (Figure N-1). In December 2000, AFCEE, with concurrence from the regulatory agencies, turned off one recirculating well because TCE concentrations in groundwater in the vicinity of the well had reached cleanup levels. In April 2003, the second recirculating well was shut down and in February 2004 the SD-5S extraction well was shut down because TCE concentrations had either reached cleanup levels or it was determined continued system operation would not further contribute to aquifer restoration. In 2006, AFCEE issued a Record of Decision, which specified the final remedy for the SD-5 groundwater plume as long term monitoring (LTM) with Land Use Controls (AFCEE 2006).

Due to the effectiveness of the groundwater remediation systems at SD-5 and due to the processes of natural attenuation, TCE detections at concentrations above the MCL are now only reported at one location in SD-5S (AFCEE 2010) and the SD-5 groundwater plume has not been defined as a contiguous plume since 2005. For the purposes of this vapor intrusion (VI)

evaluation, the historical delineation of the SD-5 plume from 1999 is shown on the supporting figures to illustrate its former location and extent. As part of the SD-5 LTM program, AFCEE continues to monitor the natural attenuation of the remaining TCE in the SD-5 area biennially at three monitoring wells (Figure N-1). Past studies have shown that the SD-5S plume discharged to Johns Pond; however, no plume contaminants were detected in Johns Pond surface water when last sampled in July 2011 as part of AFCEE's Recreational Beach Monitoring Program (AFCEE 2012).

A plan view of the historic extent of the SD-5N plume, along with the location of a line of cross-section through the SD-5N area is shown on Figure N-2. A cross-sectional view of the SD-5N area is provided as Figure N-3. Figure N-4 compares the most recent groundwater data collected from monitoring wells screened at or near the water-table in the SD-5N area to VI groundwater-to-indoor air screening values. Figure N-4 also shows the proximity of the Fire Training Area-2/Landfill-2 (FTA-2/LF-2) site to the west of SD-5N and the Petroleum Fuel Storage Area (PFSA) site to the east of SD-5 near the MMR base boundary. VI evaluations for these sites, which are primarily the result of petroleum hydrocarbon releases, are included in this document as Appendices P and O, respectively. For completeness, the groundwater data associated with FTA-2/LF-2 and PFSA are included on Figure N-4. Figure N-5 shows the locations of subsurface utilities below the SD-5N area. A plan view of the historic extent of the SD-5S plume, along with the location of a line of cross-section through the SD-5S area is shown on Figure N-6. A cross-sectional view through the SD-5S area is provided as Figure N-7.

Buildings located close to the former footprint of the SD-5N plume consist of Building 3132 to the north (the MMR Fire Station) and Buildings 561 (AFCEE's Sandwich Road Treatment Facility) and 587 (AFCEE's Operations and Maintenance Building) to the south (Figure N-4). Building 175, an aircraft hangar building formerly located north of South Outer Road, was demolished in 2011, and structures associated with the PFSA were demolished in 2010/2011. Within the footprint of the historic SD-5S plume located off-base, buildings consist of private residences. Characteristic of many of the MMR groundwater plumes, the SD-5 plume descended in the aquifer as it migrated from its source area due to recharge accretion, resulting in the plume

being located relatively deep in the aquifer by the time it migrated off-base. Consequently, the majority of SD-5S was overlain by a lens of clean groundwater when the plume existed.

The topography of the land above the historic SD-5 plume footprint is generally flat but slightly undulating with a ground elevation change of approximately 78 feet (ft) within the historic footprint of the plume. Sub-regionally, the area is characterized by low rolling hills and flat areas of the Mashpee Pitted Plain, which is a broad, flat, gently southward-sloping glacial outwash plain (AFCEE 2004). Within the footprint of the historic plume, the maximum and minimum ground surface elevations are approximately 116 ft mean sea level (msl), and 38 ft msl, respectively.

The groundwater flow direction in the vicinity of the historic SD-5 plume is generally to the south-southeast, and flow within the aquifer is primarily horizontal with stronger vertical gradients near Johns Pond due to the hydraulic influence of the pond on the groundwater flow field. The depth to groundwater within the historic SD-5 plume footprint ranges from 60 ft below ground surface near the source area to less than a few feet where the plume previously discharged to Johns Pond. The elevation of the water table is approximately 55 ft msl below the former source area and approximately 35 ft msl at the former Johns Pond discharge area, indicating a relatively low hydraulic gradient. The aquifer saturated thickness in the SD-5 area ranges up to approximately 250 ft (AFCEE 2002).

N1.2 STEP 1: CLEAN WATER LENS

As established in Section 4.1.1 and depicted graphically in Figure 4-1 of the main document, the first step in evaluating the possibility of VI for a groundwater plume is determining whether a continuous 3-ft-thick clean water lens is present above the entire plume and is expected to remain for the foreseeable future as long as the plume exists. If the evaluation indicates that a clean water lens is present using the criteria presented in Section 4.1.1 of the main document, it can be concluded that the VI pathway is incomplete and no further evaluation is required.

The clean water lens evaluation at SD-5 included a review of available VOC analytical data collected at SD-5. For this SD-5 VI evaluation, the absence of plume-related VOC detections in

groundwater at the water table (and extending at least 3 ft into the saturated zone) defines the presence of a clean water lens. The following subsections evaluate the clean water lens for the SD-5N and SD-5S areas.

N1.2.1 SD-5N

The locations of all the monitoring points used for the SD-5N VI evaluation are shown on Figure N-2 and N-4, and the TCE data used to support this evaluation are shown on the north-south cross-sectional depiction on Figure N-3. The supporting analytical data are summarized in Table N-1. Well construction and sampling location information is included in Table N-2.

As described in the conceptual site model (CSM) in Section N1.1, recent TCE concentrations in groundwater at SD-5N are below the MCL and the plume has not been defined since 2005. However, data collected under the SD-5 LTM program as recently as 2010 (AFCEE 2010) indicate that detectable concentrations of TCE remain in groundwater at the water table (Figure N-3). PCE detections also remain at SD-5N monitoring wells screened at or near the water table (Table N-1). Therefore, a clean water lens does not exist at SD-5N and an incomplete VI pathway cannot be ruled out. Further VI evaluation (i.e., Step 2 of the VI evaluation process) is warranted for SD-5N.

N1.2.2 SD-5S

The locations of all the monitoring points used for the SD-5S VI evaluation are shown on Figure N-6, and the TCE data used to support this evaluation are shown on the northwest-southeast cross-sectional depiction on Figure N-7. The supporting analytical data are summarized in Table N-1. Well construction and sampling location information is included in Table N-2.

As described in the CSM in Section N1.1, characterization and monitoring data collected at SD-5S indicate the plume descended in the aquifer as it migrated away from the source area and became overlain by a lens of clean groundwater by the time it migrated off-base. Furthermore, due to the effectiveness of the groundwater remediation systems at SD-5S and through the processes of natural attenuation, detectable concentrations of TCE are only reported at limited

monitoring wells located deeper in the aquifer between Ashumet and Johns Pond (Figure N-7). Characterization and monitoring data collected under the SD-5 LTM program from shallower intervals confirm that the remaining SD-5S residual TCE and PCE detections are overlain by a substantial thickness of clean water well in excess of 3 ft. The data that support this aspect of the CSM are as follows:

- Groundwater vertical profile data collected in 2004 at 28DP0001 and 28DP0002, once located within the former plume footprint, indicate the presence of at least a 50 ft thickness of clean water.
- Monitoring data from 91MW0522C, 91MW0522D, 28MW0032B, 28MW0032C, 00MW0524E, 00MW0526X, ECMWJNP01M, and ECMWJNP01S collected between 1997 and 2002 indicate the presence of a clean water lens in excess of 3 ft along the entire former SD-5S plume footprint between Ashumet Pond and Johns Pond.

In summary, characterization and monitoring data from multiple locations throughout the area of the historic SD-5S plume footprint confirm the presence of a clean water lens in excess of the 3-ft thickness criterion used for this VI screening evaluation. It is acknowledged, however, that some of these characterization data are not recent (i.e., dating back to 1997 in some cases). However, when combined with more recent vertical profile data collected in 2004 and the overall understanding of the hydrogeologic aspect of the CSM, they still provide sound lines of evidence that the remaining residual contaminant detections associated with SD-5S are located deep in the aquifer and are overlain by a substantial thickness of clean water which is not anticipated to change in the future. Therefore, further VI evaluation for SD-5S is not necessary.

N1.3 STEP 2: BUILDINGS AND PREFERENTIAL AIRFLOW PATHWAYS

If it is determined that a constant 3-ft-thick lens of clean water does not exist or its presence cannot be demonstrated with an adequate level of certainty, the next step in the VI assessment is the evaluation of the proximity of potential receptors (Section 4.1.2 of main document). This is only necessary for SD-5N.

N1.3.1 SD-5N

As shown on Figure N-4, there is a detection of PCE which is a SD-5N VI contaminant of potential concern (COPC) within 100 ft of Building 3132 (at 28MW0101). SD-5N related VI

COPCs (PCE and TCE) have also been detected within 100 ft of potential preferential airflow pathways. Examples include VI COPC detections at 28MW0101 and 28MW0102, adjacent to the water, wastewater, and storm water lines off Richardson Road, and at 28MW0010, adjacent to the water line located along Branshaw Street (Figures N-4 and N-5). Thus, due to the proximity of these water table VI COPC detections to existing buildings and preferential airflow pathways, further VI evaluation (i.e., Step 3 of the groundwater VI evaluation process) is needed for SD-5N.

The VI COPC detections near Buildings 561 and 587 are not SD-5 related. Refer to the VI evaluation for PFSA in Appendix O for further discussion.

N1.4 STEP 3: COMPARE GROUNDWATER CONCENTRATIONS TO VI SCREENING VALUES

Table N-1 compares the latest available VI COPC concentrations detected in groundwater collected at or near the water table to the groundwater-to-indoor-air screening values specified in Table 4-1 of the main document. Locations with sampling data that exceed a screening value for one or more of the VI COPCs are indicated on Figure N-4. Section 4.1.3 of main document outlines this step in detail.

N1.4.1 SD-5N

As shown on Figure N-4, detection of SD-5-related VI COPCs do exist at or near the water table within 100 ft of Buildings 3132 and preferential airflow pathways; however, the concentrations are all below the VI screening values (Table N-1). Since the SD-5N area has no ongoing source of groundwater contamination, characterization data are adequate (Figure N-4), and concentrations are expected to continue to decline, it can be concluded that the VI exposure pathway at SD-5N is considered insignificant.

It is acknowledged that exceedances of VI screening values are present to the west of the historic SD-5N plume footprint, which are attributed to petroleum-related constituents from the FTA-2 area. As discussed in Appendix P, VI impacts from FTA-2 area groundwater are unlikely and no further VI evaluation is recommended relative to FTA-2. In addition, exceedances of VI

screening values are present to the east of the historic SD-5 plume footprint near the MMR base boundary but these are petroleum-related constituents associated with the PFSA site. As presented in VI evaluation for PFSA in Appendix O, a VI risk above target levels cannot be ruled out at PFSA and additional VI evaluation is warranted. Further details of recommended actions at PFSA are presented in Appendix O.

N2.0 CONCLUSIONS AND RECOMMENDATIONS

N2.1 CONCLUSIONS

A review of groundwater characterization and monitoring data collected at SD-5 indicates that a continuous clean water lens at least 3 ft thick is present above the residual SD-5S related TCE and PCE detections and is expected to be present in the future as long as detections exist. However, a clean water lens is not present in the vicinity of the historic SD-5N plume. SD-5 related VI COPCs (TCE and PCE) have been detected in groundwater at or near the water table within 100 ft of buildings and within 100 ft of subsurface utilities at SD-5N. These findings necessitated further evaluation.

In all of the cases where detectable concentrations of PCE and/or TCE have been identified at the water table at SD-5N, the concentrations are below the groundwater-to-indoor VI screening values presented in Table 4-1 of the main document. Therefore, the VI pathway is considered insignificant in these areas since the residual concentrations of TCE and/or PCE are unlikely to result in VI risks above target levels. In addition, since no ongoing source of contamination is present and LTM data indicate declining concentration trends throughout the SD-5N area, higher concentrations are not anticipated in the future. Thus VI concerns are unwarranted based on either an insignificant (SD-5N) or incomplete (SD-5S) exposure pathway.

N2.2 RECOMMENDATIONS

No further monitoring or data collection is needed specific to VI at SD-5. However, as part of the ongoing LTM program at SD-5, AFCEE will continue to monitor the attenuation of the residual TCE and PCE concentrations and will re-evaluate the VI exposure pathway if conditions change such that VI could be a concern.

N3.0 REFERENCES

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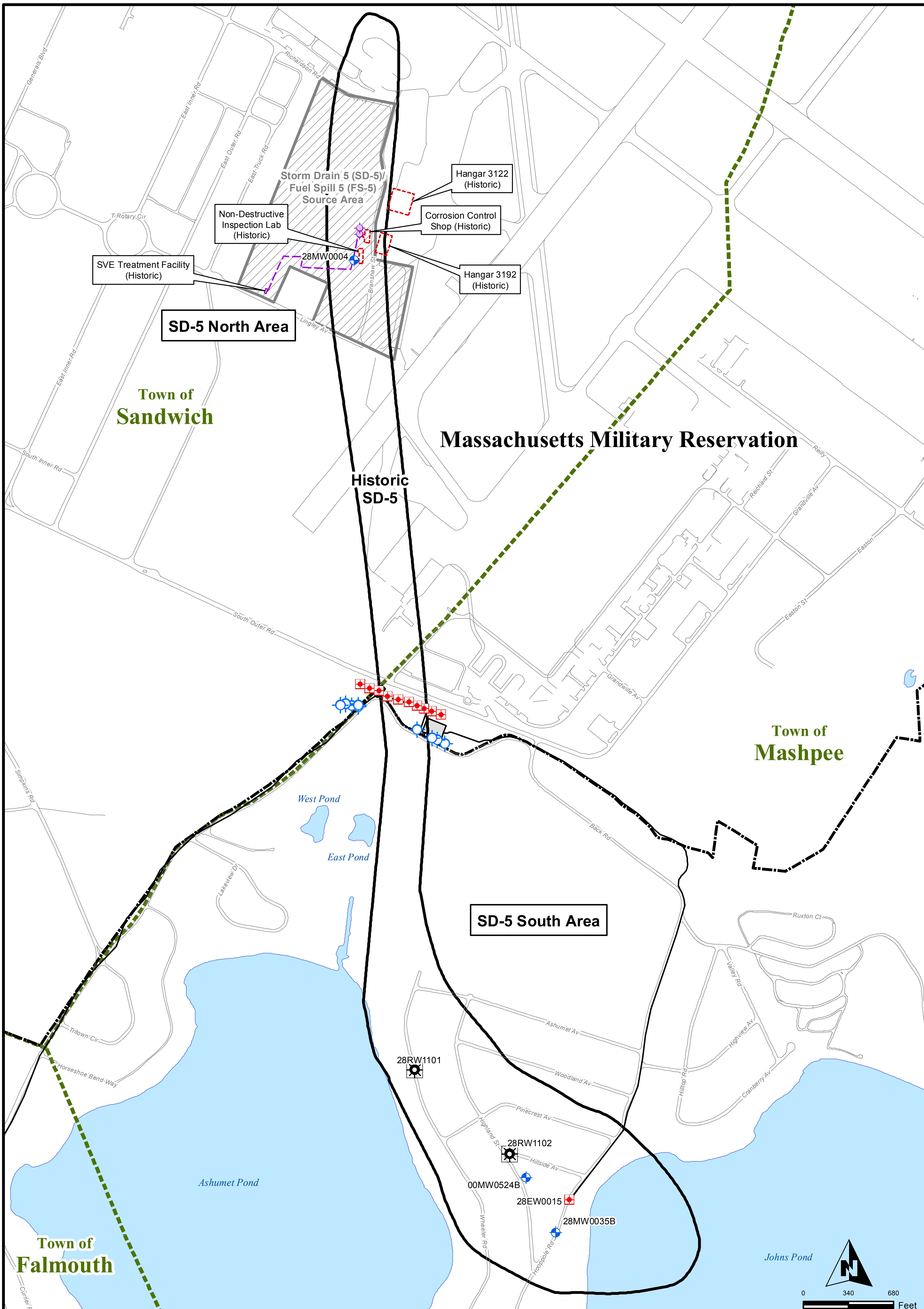

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Data Source: AFCEE, June 2012, MMR-AFCEE Data Warehouse
MMR Boundary from Massachusetts Air National Guard 2011

Legend

- Extraction Well (Off)
- Reinjection Well (On)
- SD-5 LTM Location
- Recirculating Well (Off)
- Treatment Plant
- Historic SVE Extraction Well
- Massachusetts Military Reservation Boundary
- Treatment System Piping
- Town Boundary
- Historic SVE Treatment Pipeline
- Historic SD-5 Plume Boundary (1999)
- SD-5/FS-5 Source Area

FIGURE N-1

SD-5 NORTH AND SOUTH AREAS

AFCEE - Massachusetts Military Reservation

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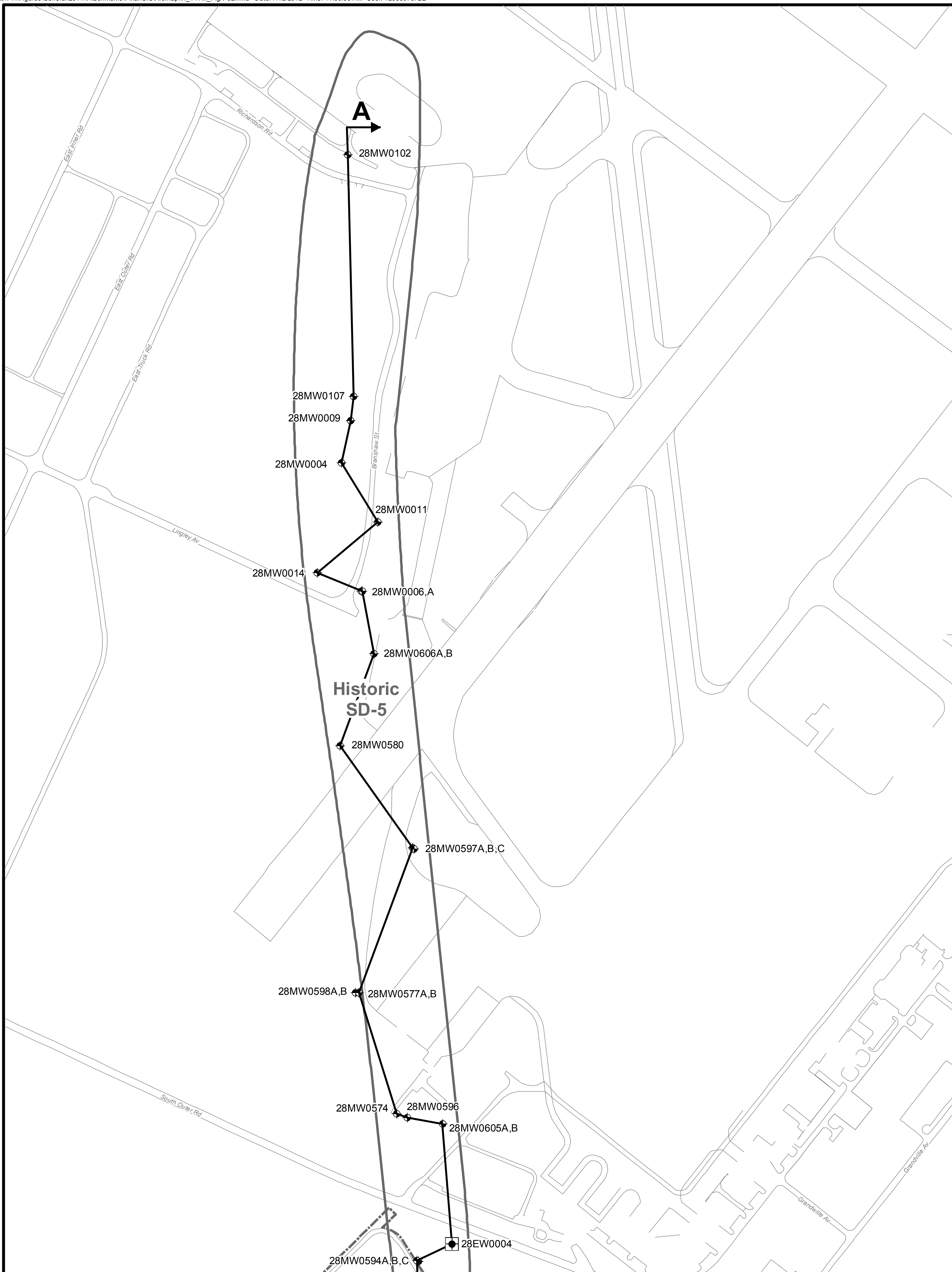

Data Source: AFCEE, June 2012, MMR-AFCEE Data Warehouse
MMR Boundary from Massachusetts Air National Guard 2011

Legend

- Extraction Well (Off)
- Monitoring Well
- Massachusetts Military Reservation Boundary
- Historic SD-5 Plume Boundary (1999)
- A' Location of Cross-section

N

0 220 440 Feet

FIGURE N-2

SD-5 NORTH GROUNDWATER PLUME AND LOCATION OF CROSS-SECTION LINE

AFCEE - Massachusetts Military Reservation

Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

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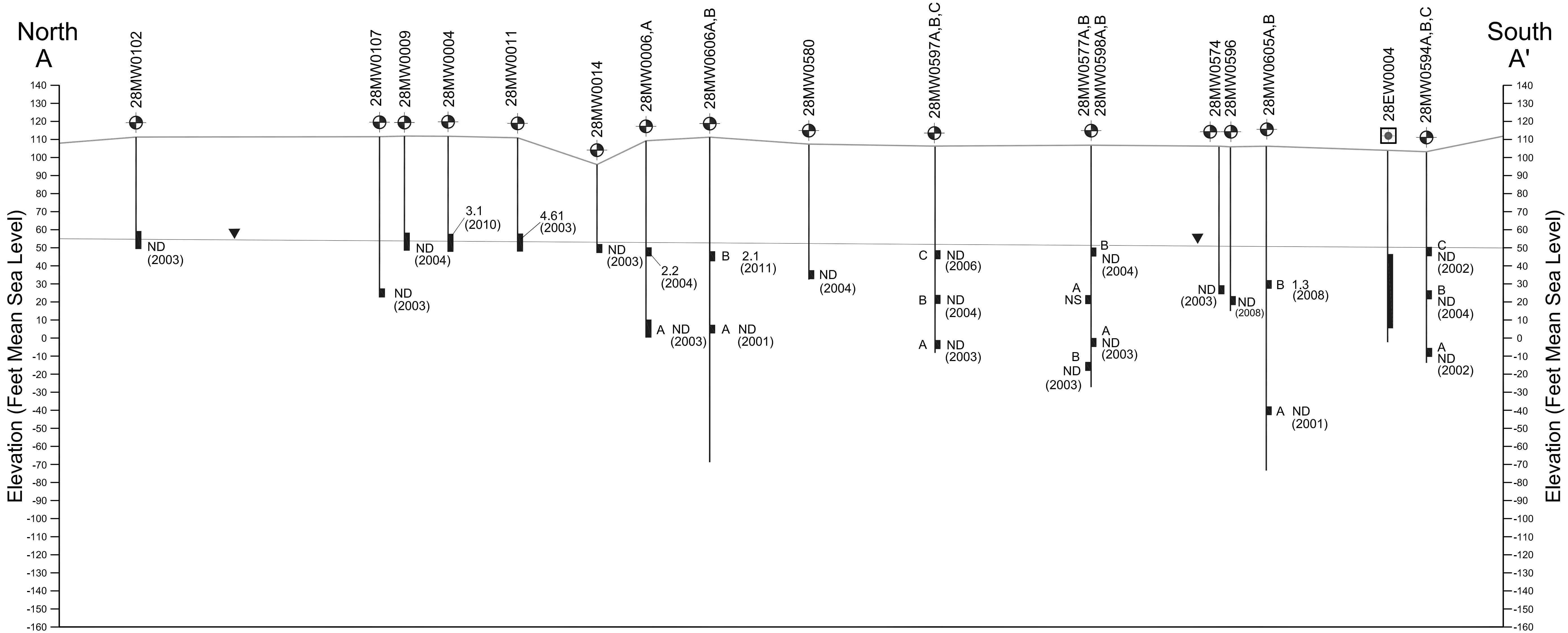

Legend

	Monitoring Well		Water Table	NS	Not Sampled
	Extraction Well (Off)	3.1	TCE Results (µg/L) (Date Sampled)	ND	Not Detected
A	Well Screen ID		Sand		

Data Source: AFCEE, June 2012, AFCEE-MMR Data Warehouse.

0 V: 60 H: 400 Feet

FIGURE N-3

SD-5 NORTH CROSS-SECTION A-A'

AFCEE - Massachusetts Military Reservation
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

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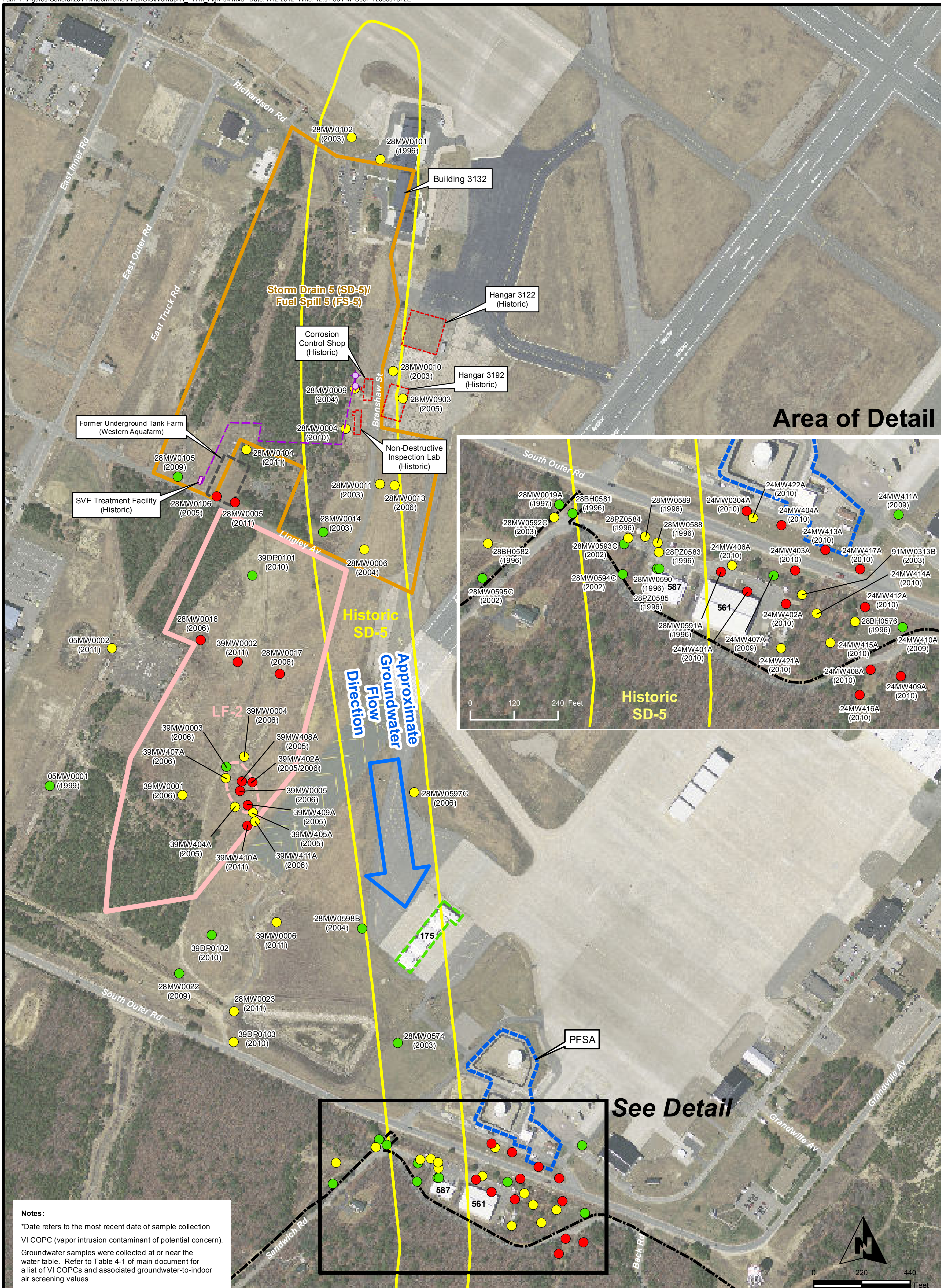

Notes:

*Date refers to the most recent date of sample collection

VI COPC (vapor intrusion contaminant of potential concern).

Groundwater samples were collected at or near the water table. Refer to Table 4-1 of main document for a list of VI COPCs and associated groundwater-to-indoor air screening values.

Legend

- FTA-2 Source Area
- SD-5/FS-5 Source Area
- Historic Tank Farm (Western Aquafarm)
- Historic Building Footprint
- LF-2 Boundary
- Historic SD-5 Plume Boundary (1999)
- Building 175 Demolished 2011
- PFSA Structures Demolished 2011
- Massachusetts Military Reservation Boundary
- Historic SVE Treatment Pipeline
- 175 Building Number
- Historic SVE Extraction Well
- (2010) Locations with an Exceedance of a VI COPC Screening Value*
- (2010) Locations With VI COPC Detection Below Its Screening Values*
- (2009) Locations With No VI COPC Detections*

Data Source: AFCEE, June 2012, MMR-AFCEE Data Warehouse
MMR Boundary from Massachusetts Air National Guard 2011
2009 Aerial Photography from MassGIS

FIGURE N-4

SD-5 NORTH GROUNDWATER DATA SUMMARY

AFCEE - Massachusetts Military Reservation

Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

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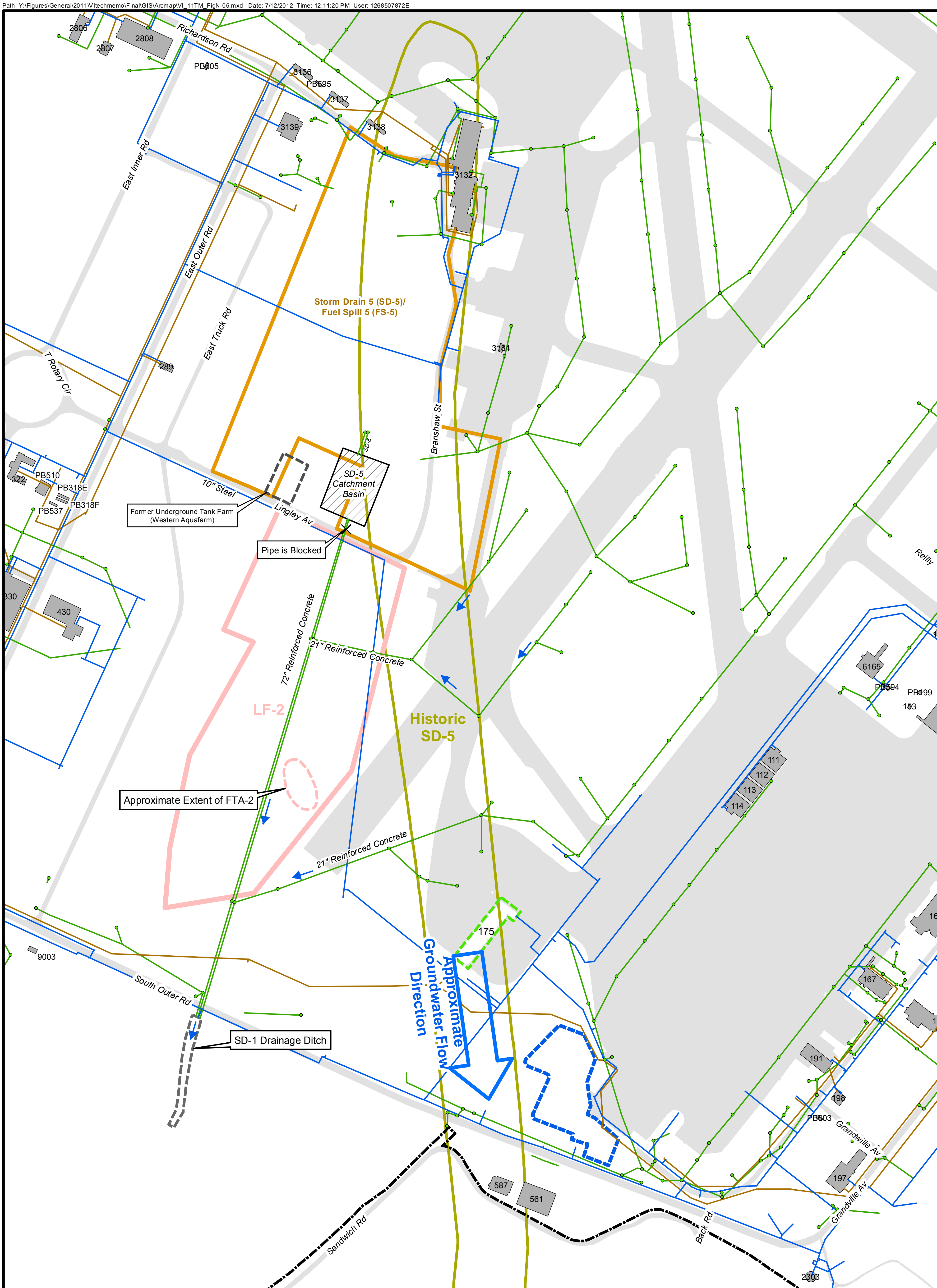
Path: Y:\Figures\General\2011\VItechmemo\Final\GIS\Arcmap\VI_11TM_FigN-05.mxd Date: 7/12/2012 Time: 12:11:20 PM User: 1268507872E



Legend

- LF-2 Boundary
- Historic SD-5 Plume Boundary (1999)
- FTA-2 Source Area
- SD-5/FS-5 Source Area
- Historic Tank Farm (Western Aquafarm)
- Wastewater Pipe
- Water Supply Pipe
- Storm Water Pipe
- Building 175 Demolished 2011
- PFSA Structures Demolished 2011
- Storm Water Inlet Point
- Existing Building
- Pavement/Surface Road
- Direction of Flow
- 175 Building Number

Data Source: AFCEE, June 2012, MMR-AFCEE Data Warehouse
January 2012 GIS Data from Massachusetts Air National Guard

0 220 440
Feet

FIGURE N-5

SD-5 NORTH EXISTING SUBSURFACE UTILITIES

AFCEE - Massachusetts Military Reservation

Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

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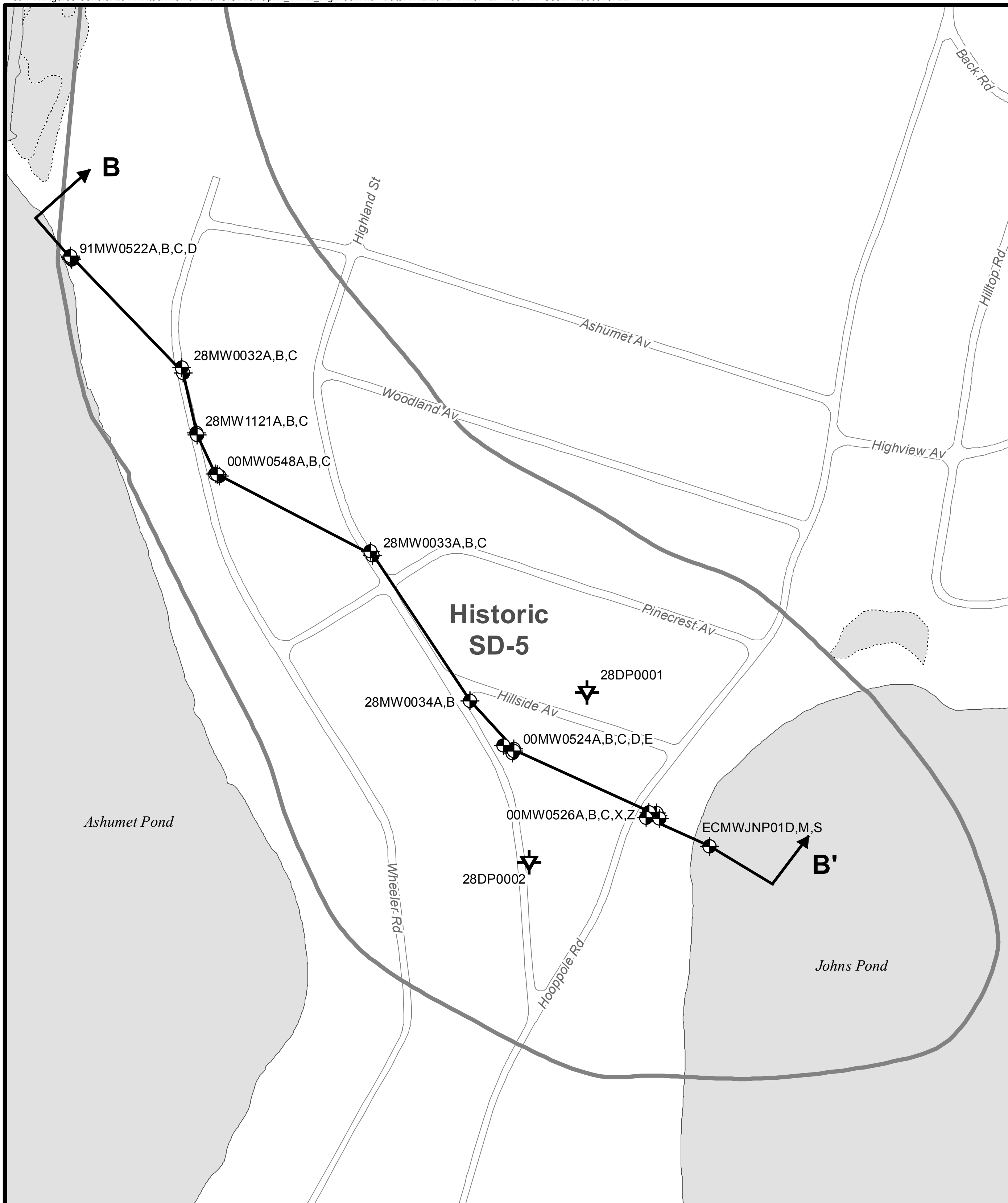

Data Source: AFCEE, June 2012, MMR-AFCEE Data Warehouse

Legend

- Historic SD-5 Plume Boundary (1999)
- B' Cross-Section Line
- Bog/Wetland
- Monitoring Well
- Direct Push Location

N

0 190 380 Feet

FIGURE N-6

SD-5 SOUTH LOCATION OF CROSS-SECTION LINE

AFCEE - Massachusetts Military Reservation

Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

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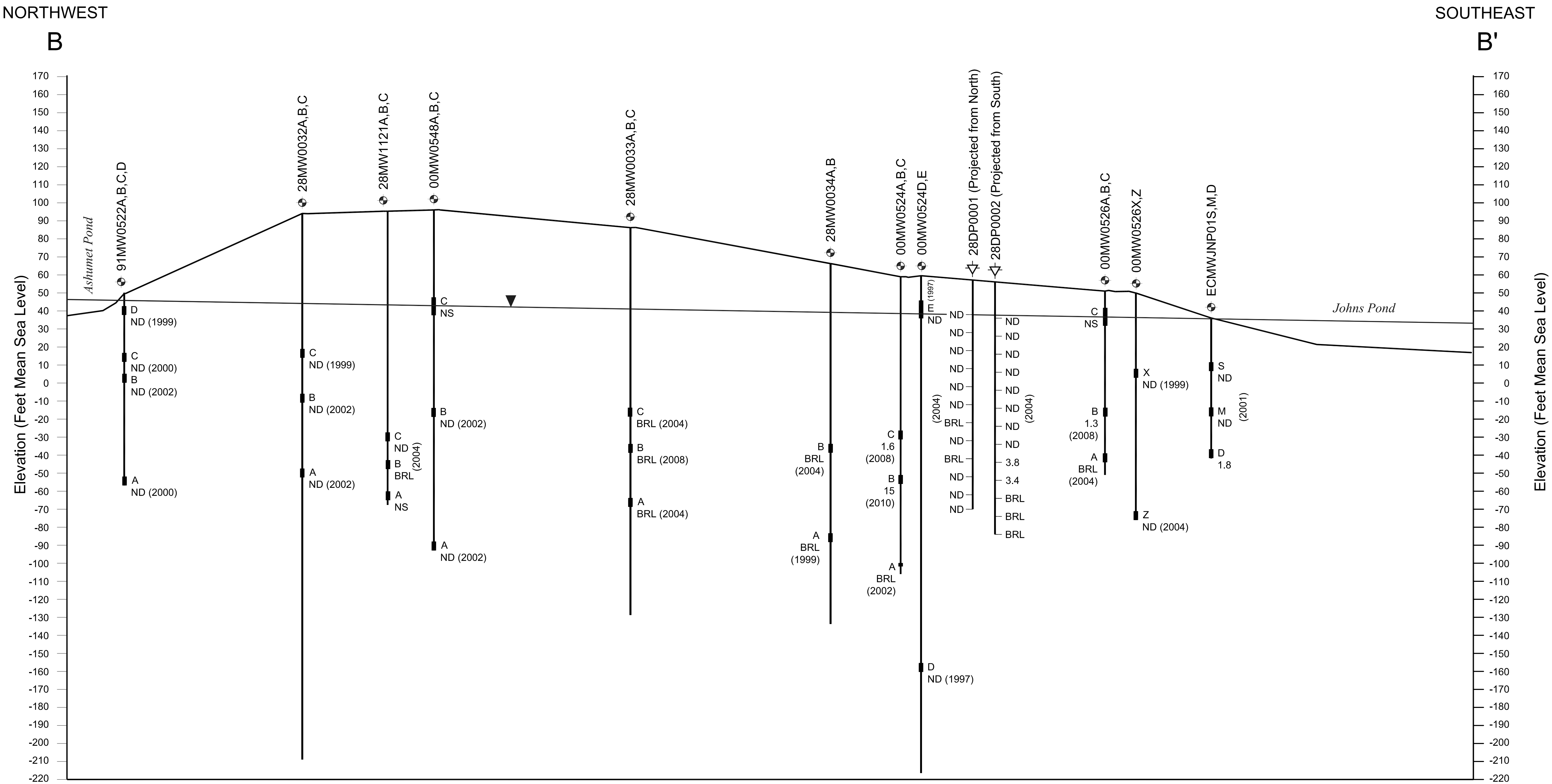

Data Source: AFCEE, June 2012, MMR-AFCEE Data Warehouse.

Legend

Monitoring Well	BRL	Below Reporting Limit	1.2 TCE Vertical Profile Data (µg/L) (Date Collected)
Direct Push Location	NS	Not Sampled	
Water Table	BRL	TCE Results (µg/L) (Date Sampled)	
ND Not Detected	A	Well Screen ID	

V: 58
H: 259
0 Feet

FIGURE N-7

SD-5 SOUTH CROSS-SECTION B-B'

AFCEE - Massachusetts Military Reservation

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Table N-1
Comparison of VI COPC Concentrations in SD-5 and Vicinity Groundwater
to Applicable Groundwater-to-Indoor Air Screening Values
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Location	Date	Mid-Screen Elevation (ft msl)	Sampling Method[1]	VI COPC[1]	Result	DL	RL	MCP Method 1 GW-2 Standard[2] (µg/L)	VI Screening Value Exceeded?	Generic Unrestricted Groundwater Screening Value[3] (µg/L)	VI Screening Value Exceeded?
					All Units = µg/L						
SD-5 North Area											
05MW0001	2/4/1999	48	MW	No VI COPCs detected	ND	--	--	--	--	--	--
05MW0002	12/21/2011	45	MW	C5-C8 ALIPHATIC HYDROCARBONS	BRL	10	20	3,000	No	NE	NA
24MW0304A	10/1/1999	57	MW	ETHYLBENZENE	18	0.38	4	20,000	No	700	No
24MW0304A	10/1/1999	57	MW	XYLENES, TOTAL	140	1.2	4	9,000	No	10,000	No
24MW401A	2/9/2010	57	MW	1,2,4-TRIMETHYLBENZENE	**14**	0.27	1	NE	NA	7.8	Yes
24MW401A	2/9/2010	57	MW	1,3,5-TRIMETHYLBENZENE (MESITYLENE)	4.1	0.21	1	NE	NA	7.8	No
24MW401A	2/9/2010	57	MW	C5-C8 ALIPHATIC HYDROCARBONS	BRL	0.76	50	3,000	No	NE	NA
24MW401A	2/9/2010	57	MW	C9-C10 AROMATIC HYDROCARBONS	93.3	1.2	50	7,000	No	NE	NA
24MW401A	2/9/2010	57	MW	C9-C12 ALIPHATIC HYDROCARBONS	59.9	1.54	50	5,000	No	NE	NA
24MW402A	2/5/2010	57	MW	1,2,4-TRIMETHYLBENZENE	**11**	0.27	1	NE	NA	7.8	Yes
24MW402A	2/5/2010	57	MW	C9-C10 AROMATIC HYDROCARBONS	61.2	1.2	50	7,000	No	NE	NA
24MW402A	2/5/2010	57	MW	ETHYLBENZENE	BRL	0.26	1	20,000	No	700	No
24MW403A	2/9/2010	57	MW	1,2,4-TRIMETHYLBENZENE	**62**	0.27	1	NE	NA	7.8	Yes
24MW403A	2/9/2010	57	MW	1,3,5-TRIMETHYLBENZENE (MESITYLENE)	**17**	0.21	1	NE	NA	7.8	Yes
24MW403A	2/9/2010	57	MW	C5-C8 ALIPHATIC HYDROCARBONS	93.2J	1.52	100	3,000	No	NE	NA
24MW403A	2/9/2010	57	MW	C9-C10 AROMATIC HYDROCARBONS	335	2.4	100	7,000	No	NE	NA
24MW403A	2/9/2010	57	MW	C9-C12 ALIPHATIC HYDROCARBONS	209	3.08	100	5,000	No	NE	NA
24MW403A	2/9/2010	57	MW	ETHYLBENZENE	BRL	0.26	1	20,000	No	700	No
24MW404A	2/8/2010	59	MW	1,2,4-TRIMETHYLBENZENE	**57**	0.27	1	NE	NA	7.8	Yes
24MW404A	2/8/2010	59	MW	1,3,5-TRIMETHYLBENZENE (MESITYLENE)	**17**	0.21	1	NE	NA	7.8	Yes
24MW404A	2/8/2010	59	MW	C11-C22 AROMATIC HYDROCARBONS	BRL	37	100	50,000	No	NE	NA
24MW404A	2/8/2010	59	MW	C5-C8 ALIPHATIC HYDROCARBONS	56.2	0.76	50	3,000	No	NE	NA
24MW404A	2/8/2010	59	MW	C9-C10 AROMATIC HYDROCARBONS	317	1.2	50	7,000	No	NE	NA
24MW404A	2/8/2010	59	MW	C9-C12 ALIPHATIC HYDROCARBONS	174	1.54	50	5,000	No	NE	NA
24MW404A	2/8/2010	59	MW	ETHYLBENZENE	1.6	0.26	1	20,000	No	700	No
24MW406A	2/16/2010	57	MW	1,2,4-TRIMETHYLBENZENE	BRL	0.27	1	NE	NA	7.8	No
24MW406A	2/16/2010	57	MW	C9-C10 AROMATIC HYDROCARBONS	BRL	1.2	50	7,000	No	NE	NA
24MW406A	2/16/2010	57	MW	C9-C12 ALIPHATIC HYDROCARBONS	BRL	1.54	50	5,000	No	NE	NA
24MW407A	2/5/2010	47	MW	No VI COPCs detected	ND	--	--	--	--	--	--
24MW408A	2/12/2010	37	MW	1,2,4-TRIMETHYLBENZENE	**67**	0.27	1	NE	NA	7.8	Yes
24MW408A	2/12/2010	37	MW	1,3,5-TRIMETHYLBENZENE (MESITYLENE)	**27**	0.21	1	NE	NA	7.8	Yes
24MW408A	2/12/2010	37	MW	C11-C22 AROMATIC HYDROCARBONS	113	37	100	50,000	No	NE	NA
24MW408A	2/12/2010	37	MW	C5-C8 ALIPHATIC HYDROCARBONS	424	0.76	50	3,000	No	NE	NA
24MW408A	2/12/2010	37	MW	C9-C10 AROMATIC HYDROCARBONS	455	1.2	50	7,000	No	NE	NA
24MW408A	2/12/2010	37	MW	C9-C12 ALIPHATIC HYDROCARBONS	77.6	1.54	50	5,000	No	NE	NA
24MW408A	2/12/2010	37	MW	C9-C18 ALIPHATIC HYDROCARBONS	BRL	6.14	100	5,000	No	NE	NA

Table N-1
Comparison of VI COPC Concentrations in SD-5 and Vicinity Groundwater
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Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Location	Date	Mid-Screen Elevation (ft msl)	Sampling Method[1]	VI COPC[1]	Result	DL	RL	MCP Method 1 GW-2 Standard[2] (µg/L)	VI Screening Value Exceeded?	Generic Unrestricted Groundwater Screening Value[3] (µg/L)	VI Screening Value Exceeded?
					All Units = µg/L						
24MW408A	2/12/2010	37	MW	ETHYLBENZENE	3.5	0.26	1	20,000	No	700	No
24MW409A	2/12/2010	47	MW	1,2,4-TRIMETHYLBENZENE	**13**	0.27	1	NE	NA	7.8	Yes
24MW409A	2/12/2010	47	MW	1,3,5-TRIMETHYLBENZENE (MESITYLENE)	1.3	0.21	1	NE	NA	7.8	No
24MW409A	2/12/2010	47	MW	C11-C22 AROMATIC HYDROCARBONS	BRL	37	100	50,000	No	NE	NA
24MW409A	2/12/2010	47	MW	C5-C8 ALIPHATIC HYDROCARBONS	69.5	0.76	50	3,000	No	NE	NA
24MW409A	2/12/2010	47	MW	C9-C10 AROMATIC HYDROCARBONS	185	1.2	50	7,000	No	NE	NA
24MW409A	2/12/2010	47	MW	C9-C12 ALIPHATIC HYDROCARBONS	BRL	1.54	50	5,000	No	NE	NA
24MW409A	2/12/2010	47	MW	C9-C18 ALIPHATIC HYDROCARBONS	BRL	6.14	100	5,000	No	NE	NA
24MW409A	2/12/2010	47	MW	ETHYLBENZENE	BRL	0.26	1	20,000	No	700	No
24MW410A	2/11/2010	43	MW	No VI COPCs detected	ND	--	--	--	--	--	--
24MW411A	1/29/2009	45	MW	No VI COPCs detected	ND	--	--	--	--	--	--
24MW412A	2/11/2010	47	MW	1,2,4-TRIMETHYLBENZENE	**150**	2.7	10	NE	NA	7.8	Yes
24MW412A	2/11/2010	47	MW	1,3,5-TRIMETHYLBENZENE (MESITYLENE)	**61**	2.1	10	NE	NA	7.8	Yes
24MW412A	2/11/2010	47	MW	C11-C22 AROMATIC HYDROCARBONS	BRL	38.1	103	50,000	No	NE	NA
24MW412A	2/11/2010	47	MW	C5-C8 ALIPHATIC HYDROCARBONS	400	0.76	50	3,000	No	NE	NA
24MW412A	2/11/2010	47	MW	C9-C10 AROMATIC HYDROCARBONS	574	1.2	50	7,000	No	NE	NA
24MW412A	2/11/2010	47	MW	C9-C12 ALIPHATIC HYDROCARBONS	85.1	1.54	50	5,000	No	NE	NA
24MW412A	2/11/2010	47	MW	ETHYLBENZENE	88	2.6	10	20,000	No	700	No
24MW413A	2/8/2010	59	MW	1,2,4-TRIMETHYLBENZENE	**38**	0.27	1	NE	NA	7.8	Yes
24MW413A	2/8/2010	59	MW	1,3,5-TRIMETHYLBENZENE (MESITYLENE)	**19**	0.21	1	NE	NA	7.8	Yes
24MW413A	2/8/2010	59	MW	C11-C22 AROMATIC HYDROCARBONS	BRL	37	100	50,000	No	NE	NA
24MW413A	2/8/2010	59	MW	C5-C8 ALIPHATIC HYDROCARBONS	74.2	0.76	50	3,000	No	NE	NA
24MW413A	2/8/2010	59	MW	C9-C10 AROMATIC HYDROCARBONS	156	1.2	50	7,000	No	NE	NA
24MW413A	2/8/2010	59	MW	C9-C12 ALIPHATIC HYDROCARBONS	87.1	1.54	50	5,000	No	NE	NA
24MW414A	2/16/2010	57	MW	C11-C22 AROMATIC HYDROCARBONS	116	37.8	102	50,000	No	NE	NA
24MW414A	2/16/2010	57	MW	C5-C8 ALIPHATIC HYDROCARBONS	268	0.76	50	3,000	No	NE	NA
24MW414A	2/16/2010	57	MW	C9-C10 AROMATIC HYDROCARBONS	BRL	1.2	50	7,000	No	NE	NA
24MW414A	2/16/2010	57	MW	C9-C12 ALIPHATIC HYDROCARBONS	52.7	1.54	50	5,000	No	NE	NA
24MW415A	2/16/2010	49	MW	C5-C8 ALIPHATIC HYDROCARBONS	BRL	0.76	50	3,000	No	NE	NA
24MW415A	2/16/2010	49	MW	C9-C10 AROMATIC HYDROCARBONS	BRL	1.2	50	7,000	No	NE	NA
24MW415A	2/16/2010	49	MW	C9-C12 ALIPHATIC HYDROCARBONS	BRL	1.54	50	5,000	No	NE	NA
24MW416A	2/12/2010	37	MW	1,2,4-TRIMETHYLBENZENE	**8.9**	0.27	1	NE	NA	7.8	Yes
24MW416A	2/12/2010	37	MW	1,3,5-TRIMETHYLBENZENE (MESITYLENE)	4.2	0.21	1	NE	NA	7.8	No
24MW416A	2/12/2010	37	MW	C11-C22 AROMATIC HYDROCARBONS	BRL	37	100	50,000	No	NE	NA
24MW416A	2/12/2010	37	MW	C5-C8 ALIPHATIC HYDROCARBONS	149	0.76	50	3,000	No	NE	NA
24MW416A	2/12/2010	37	MW	C9-C10 AROMATIC HYDROCARBONS	98.9	1.2	50	7,000	No	NE	NA
24MW416A	2/12/2010	37	MW	C9-C12 ALIPHATIC HYDROCARBONS	BRL	1.54	50	5,000	No	NE	NA
24MW416A	2/12/2010	37	MW	C9-C18 ALIPHATIC HYDROCARBONS	BRL	6.14	100	5,000	No	NE	NA

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Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Location	Date	Mid-Screen Elevation (ft msl)	Sampling Method[1]	VI COPC[1]	Result	DL	RL	MCP Method 1 GW-2 Standard[2] (µg/L)	VI Screening Value Exceeded?	Generic Unrestricted Groundwater Screening Value[3] (µg/L)	VI Screening Value Exceeded?
					All Units = µg/L						
24MW416A	2/12/2010	37	MW	ETHYLBENZENE	1.1	0.26	1	20,000	No	700	No
24MW417A	2/8/2010	59	MW	1,3,5-TRIMETHYLBENZENE (MESITYLENE)	**66**	0.84	4	NE	NA	7.8	Yes
24MW417A	2/8/2010	59	MW	C11-C22 AROMATIC HYDROCARBONS	BRL	37	100	50,000	No	NE	NA
24MW417A	2/8/2010	59	MW	C5-C8 ALIPHATIC HYDROCARBONS	498	3.8	250	3,000	No	NE	NA
24MW417A	2/8/2010	59	MW	C9-C10 AROMATIC HYDROCARBONS	584	6	250	7,000	No	NE	NA
24MW417A	2/8/2010	59	MW	C9-C12 ALIPHATIC HYDROCARBONS	349	7.7	250	5,000	No	NE	NA
24MW417A	2/8/2010	59	MW	ETHYLBENZENE	15	1.1	4	20,000	No	700	No
24MW421A	2/5/2010	57	MW	C9-C10 AROMATIC HYDROCARBONS	BRL	1.2	50	7,000	No	NE	NA
24MW422A	2/9/2010	55	MW	1,2,4-TRIMETHYLBENZENE	**16**	0.27	1	NE	NA	7.8	Yes
24MW422A	2/9/2010	55	MW	1,3,5-TRIMETHYLBENZENE (MESITYLENE)	5.3	0.21	1	NE	NA	7.8	No
24MW422A	2/9/2010	55	MW	C5-C8 ALIPHATIC HYDROCARBONS	55	0.76	50	3,000	No	NE	NA
24MW422A	2/9/2010	55	MW	C9-C10 AROMATIC HYDROCARBONS	186	1.2	50	7,000	No	NE	NA
24MW422A	2/9/2010	55	MW	C9-C12 ALIPHATIC HYDROCARBONS	117	1.54	50	5,000	No	NE	NA
28BH0576	10/30/1996	58	VP	1,2,4-TRIMETHYLBENZENE	3.7	0.13	0.5	NE	NA	7.8	No
28BH0576	10/30/1996	58	VP	1,3,5-TRIMETHYLBENZENE (MESITYLENE)	1.7	0.14	0.5	NE	NA	7.8	No
28BH0576	10/30/1996	58	VP	ETHYLBENZENE	2.8	0.09	0.5	20,000	No	700	No
28BH0576	10/30/1996	58	VP	TRICHLOROETHENE (TCE)	BRL	0.07	0.5	30	No	5	No
28BH0581	10/30/1996	6	VP	No VI COPCs detected	ND	--	--	--	--	--	--
28BH0581	10/30/1996	11	VP	No VI COPCs detected	ND	--	--	--	--	--	--
28BH0581	10/30/1996	16	VP	No VI COPCs detected	ND	--	--	--	--	--	--
28BH0581	10/30/1996	21	VP	No VI COPCs detected	ND	--	--	--	--	--	--
28BH0581	10/30/1996	26	VP	No VI COPCs detected	ND	--	--	--	--	--	--
28BH0581	10/30/1996	36	VP	No VI COPCs detected	ND	--	--	--	--	--	--
28BH0581	10/30/1996	41	VP	No VI COPCs detected	ND	--	--	--	--	--	--
28BH0582	11/4/1996	58	VP	METHYLENE CHLORIDE	BRL	0.13	0.5	10,000	No	840	No
28MW0004	8/6/2010	50	MW	TETRACHLOROETHENE (PCE)	1	0.19	1	50	No	13	No
28MW0004	8/6/2010	50	MW	TRICHLOROETHENE (TCE)	3	0.2	1	30	No	5	No
28MW0005	12/20/2011	45	MW	1,2,4-TRIMETHYLBENZENE	**32**	0.22	1	NE	NA	7.8	Yes
28MW0005	12/20/2011	45	MW	1,3,5-TRIMETHYLBENZENE (MESITYLENE)	**42**	0.2	1	NE	NA	7.8	Yes
28MW0005	12/20/2011	45	MW	2-METHYLNAPHTHALENE	8	0.1	0.2	2,000	No	12	No
28MW0005	12/20/2011	45	MW	C5-C8 ALIPHATIC HYDROCARBONS	1,430 J	50	100	3,000	No	NE	NA
28MW0005	12/20/2011	45	MW	C9-C10 AROMATIC HYDROCARBONS	694 J	50	100	7,000	No	NE	NA
28MW0005	12/20/2011	45	MW	C9-C12 ALIPHATIC HYDROCARBONS	701 J	50	100	5,000	No	NE	NA
28MW0005	12/20/2011	45	MW	C9-C18 ALIPHATIC HYDROCARBONS	BRL	100	200	5,000	No	NE	NA
28MW0005	12/20/2011	45	MW	TOLUENE	BRL	0.2	1	50,000	No	4,100	No
28MW0006	9/30/2004	47	MW	TETRACHLOROETHENE (PCE)	BRL	0.18	1	50	No	13	No
28MW0006	9/30/2004	47	MW	TRICHLOROETHENE (TCE)	2	0.11	1	30	No	5	No
28MW0009	9/30/2004	48	MW	TETRACHLOROETHENE (PCE)	BRL	0.18	1	50	No	13	No

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Location	Date	Mid-Screen Elevation (ft msl)	Sampling Method[1]	VI COPC[1]	Result	DL	RL	MCP Method 1 GW-2 Standard[2] (µg/L)	VI Screening Value Exceeded?	Generic Unrestricted Groundwater Screening Value[3] (µg/L)	VI Screening Value Exceeded?
					All Units = µg/L						
28MW0010	3/6/2003	49	MW	TETRACHLOROETHENE (PCE)	BRL	0.146	1	50	No	13	No
28MW0010	3/6/2003	49	MW	TRICHLOROETHENE (TCE)	BRL	0.138	1	30	No	5	No
28MW0010	3/6/2003	54	MW	TETRACHLOROETHENE (PCE)	BRL	0.146	1	50	No	13	No
28MW0010	3/6/2003	54	MW	TRICHLOROETHENE (TCE)	BRL	0.138	1	30	No	5	No
28MW0011	3/4/2003	48	MW	TETRACHLOROETHENE (PCE)	BRL	0.146	1	50	No	13	No
28MW0011	3/4/2003	48	MW	TRICHLOROETHENE (TCE)	5	0.138	1	30	No	5	No
28MW0013	8/9/2006	49	MW	TETRACHLOROETHENE (PCE)	3	0.15	1	50	No	13	No
28MW0013	8/9/2006	49	MW	TRICHLOROETHENE (TCE)	BRL	0.15	1	30	No	5	No
28MW0014	6/24/2003	47	MW	No VI COPCs detected	ND	--	--	--	--	--	--
28MW0016	11/1/2006	47	MW	1,2,4-TRIMETHYLBENZENE	**880**	0.9	10	NE	NA	7.8	Yes
28MW0016	11/1/2006	47	MW	1,3,5-TRIMETHYLBENZENE (MESITYLENE)	**480**	0.7	10	NE	NA	7.8	Yes
28MW0016	11/1/2006	47	MW	C5-C8 ALIPHATIC HYDROCARBONS	**3,600**	100	100	3,000	Yes	NE	NA
28MW0016	11/1/2006	47	MW	C9-C10 AROMATIC HYDROCARBONS	3,000	100	100	7,000	No	NE	NA
28MW0016	11/1/2006	47	MW	C9-C12 ALIPHATIC HYDROCARBONS	570	100	100	5,000	No	NE	NA
28MW0016	11/1/2006	47	MW	ETHYLBENZENE	BRL	0.6	5	20,000	No	700	No
28MW0016	11/1/2006	47	MW	M,P-XYLENE (SUM OF ISOMERS)	BRL	0.95	10	9,000	No	10,000	No
28MW0016	11/1/2006	47	MW	TOLUENE	BRL	0.55	5	50,000	No	4,100	No
28MW0017	11/1/2006	46	MW	1,2,4-TRIMETHYLBENZENE	**223**	0.45	5	NE	NA	7.8	Yes
28MW0017	11/1/2006	46	MW	1,3,5-TRIMETHYLBENZENE (MESITYLENE)	**124**	0.14	2	NE	NA	7.8	Yes
28MW0017	11/1/2006	46	MW	2-METHYLNAPHTHALENE	2	0.5	0.5	2,000	No	12	No
28MW0017	11/1/2006	46	MW	C5-C8 ALIPHATIC HYDROCARBONS	2,000	40	40	3,000	No	NE	NA
28MW0017	11/1/2006	46	MW	C9-C10 AROMATIC HYDROCARBONS	830	40	40	7,000	No	NE	NA
28MW0017	11/1/2006	46	MW	C9-C12 ALIPHATIC HYDROCARBONS	290	40	40	5,000	No	NE	NA
28MW0017	11/1/2006	46	MW	ETHYLBENZENE	88	10	10	20,000	No	700	No
28MW0017	11/1/2006	46	MW	M,P-XYLENE (SUM OF ISOMERS)	340	10	10	9,000	No	10,000	No
28MW0017	11/1/2006	46	MW	NAPHTHALENE	**20**	10	10	1,000	No	12	Yes
28MW0017	11/1/2006	46	MW	O-XYLENE (1,2-DIMETHYLBENZENE)	110	10	10	9,000	No	10,000	No
28MW0019A	9/25/1997	27	MW	No VI COPCs detected	ND	--	--	--	--	--	--
28MW0022	3/30/2009	37	MW	No VI COPCs detected	ND	--	--	--	--	--	--
28MW0023	12/21/2011	36	MW	C5-C8 ALIPHATIC HYDROCARBONS	264	10	20	3,000	No	NE	NA
28MW0101	9/18/1996	57	MW	TETRACHLOROETHENE (PCE)	6J	1	10	50	No	13	No
28MW0102	3/28/2003	54	MW	TETRACHLOROETHENE (PCE)	1.96	0.137	1	50	No	13	No
28MW0104	12/20/2011	46	MW	C5-C8 ALIPHATIC HYDROCARBONS	BRL	10	20	3,000	No	NE	NA
28MW0105	3/31/2009	49	MW	No VI COPCs detected	ND	--	--	--	--	--	--
28MW0106	12/30/2005	48	MW	1,2,4-TRIMETHYLBENZENE	**9**	0.55	5	NE	NA	7.8	Yes
28MW0106	12/30/2005	48	MW	1,3,5-TRIMETHYLBENZENE (MESITYLENE)	**13**	0.85	5	NE	NA	7.8	Yes
28MW0574	2/26/2003	27	MW	No VI COPCs detected	ND	--	--	--	--	--	--
28MW0588	12/9/1996	52	VP	TOLUENE	1	0.13	0.5	50,000	No	4,100	No
28MW0589	12/5/1996	53	VP	TOLUENE	2	0.13	0.5	50,000	No	4,100	No
28MW0590	12/10/1996	51	MW	No VI COPCs detected	ND	--	--	--	--	--	--
28MW0591A	12/16/1996	63	VP	1,2,4-TRIMETHYLBENZENE	**17**	0.13	0.5	NE	NA	7.8	Yes
28MW0591A	12/16/1996	63	VP	ETHYLBENZENE	9.6	0.09	0.5	20,000	No	700	No
28MW0591A	12/16/1996	63	VP	TOLUENE	BRL	0.07	0.5	50,000	No	4,100	No
28MW0592C	2/10/2003	62	MW	TETRACHLOROETHENE (PCE)	BRL	0.146	1	50	No	13	No

Table N-1
Comparison of VI COPC Concentrations in SD-5 and Vicinity Groundwater to Applicable Groundwater-to-Indoor Air Screening Values
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Location	Date	Mid-Screen Elevation (ft msl)	Sampling Method[1]	VI COPC[1]	Result	DL	RL	MCP Method 1 GW-2 Standard[2] (µg/L)	VI Screening Value Exceeded?	Generic Unrestricted Groundwater Screening Value[3] (µg/L)	VI Screening Value Exceeded?
					All Units = µg/L						
28MW0593C	8/20/2002	42	MW	No VI COPCs detected	ND	--	--	--	--	--	--
28MW0594C	8/21/2002	48	MW	No VI COPCs detected	ND	--	--	--	--	--	--
28MW0595C	8/22/2002	42	MW	No VI COPCs detected	ND	--	--	--	--	--	--
28MW0597C	8/31/2006	44	MW	TETRACHLOROETHENE (PCE)	BRL	0.15	1	50	No	13	No
28MW0598B	10/6/2004	45	MW	No VI COPCs detected	ND	--	--	--	--	--	--
28MW0903	2/24/2005	57	MW	TETRACHLOROETHENE (PCE)	2.7	0.18	1	50	No	13	No
28MW0903	2/24/2005	57	MW	TRICHLOROETHENE (TCE)	BRL	0.11	1	30	No	5	No
28PZ0583	11/6/1996	58	VP	TOLUENE	BRL	0.07	0.5	50,000	No	4,100	No
28PZ0584	11/11/1996	58	VP	METHYLENE CHLORIDE	BRL	1.08	2	10,000	No	840	No
28PZ0585	11/13/1996	46	VP	No VI COPCs detected	ND	--	--	--	--	--	--
39DP0101	6/7/2010	56	MW	No VI COPCs detected	ND	--	--	--	--	--	--
39DP0102	6/11/2010	52	MW	No VI COPCs detected	ND	--	--	--	--	--	--
39DP0103	6/8/2010	50	MW	NAPHTHALENE	BRL	0.134	0.4	1,000	No	12	No
39MW0001	11/2/2006	47	MW	CARBON TETRACHLORIDE	BRL	0.15	1	2	No	5	No
39MW0002	12/21/2011	40	MW	1,2,4-TRIMETHYLBENZENE	**1,120**	4.4	20	NE	NA	7.8	Yes
39MW0002	12/21/2011	40	MW	1,3,5-TRIMETHYLBENZENE (MESITYLENE)	**494**	4	20	NE	NA	7.8	Yes
39MW0002	12/21/2011	40	MW	2-METHYLNAPHTHALENE	**28**	2	4	2,000	No	12	Yes
39MW0002	12/21/2011	40	MW	C5-C8 ALIPHATIC HYDROCARBONS	**4,580 J**	200	400	3,000	Yes	NE	NA
39MW0002	12/21/2011	40	MW	C9-C10 AROMATIC HYDROCARBONS	4,140	200	400	7,000	No	NE	NA
39MW0002	12/21/2011	40	MW	C9-C12 ALIPHATIC HYDROCARBONS	**5,670**	200	400	5,000	Yes	NE	NA
39MW0002	12/21/2011	40	MW	C9-C18 ALIPHATIC HYDROCARBONS	235	100	200	5,000	No	NE	NA
39MW0002	12/21/2011	40	MW	ETHYLBENZENE	559	4	20	20,000	No	700	No
39MW0002	12/21/2011	40	MW	M,P-XYLENE (SUM OF ISOMERS)	2,270	8	20	9,000	No	10,000	No
39MW0002	12/21/2011	40	MW	NAPHTHALENE	**125**	2	4	1,000	No	12	Yes
39MW0002	12/21/2011	40	MW	O-XYLENE (1,2-DIMETHYLBENZENE)	688	4	20	9,000	No	10,000	No
39MW0002	12/21/2011	40	MW	TETRACHLOROETHENE (PCE)	BRL	0.19	1	50	No	13	No
39MW0002	12/21/2011	40	MW	TOLUENE	6	0.2	1	50,000	No	4,100	No
39MW0002	12/21/2011	40	MW	TRICHLOROETHENE (TCE)	BRL	0.2	1	30	No	5	No
39MW0003	11/1/2006	45	MW	No VI COPCs detected	ND	--	--	--	--	--	--
39MW0004	11/1/2006	50	MW	TRICHLOROETHENE (TCE)	BRL	0.15	1	30	No	5	No
39MW0005	11/2/2006	48	MW	1,2,4-TRIMETHYLBENZENE	**10**	0.09	1	NE	NA	7.8	Yes
39MW0005	11/2/2006	48	MW	2-METHYLNAPHTHALENE	**17**	0.56	0.56	2,000	No	12	Yes
39MW0005	11/2/2006	48	MW	C11-C22 AROMATIC HYDROCARBONS	470	170	170	50,000	No	NE	NA
39MW0005	11/2/2006	48	MW	C5-C8 ALIPHATIC HYDROCARBONS	50	20	20	3,000	No	NE	NA
39MW0005	11/2/2006	48	MW	C9-C10 AROMATIC HYDROCARBONS	480	20	20	7,000	No	NE	NA
39MW0005	11/2/2006	48	MW	C9-C12 ALIPHATIC HYDROCARBONS	180	20	20	5,000	No	NE	NA
39MW0005	11/2/2006	48	MW	cis-1,2-DICHLOROETHENE	3	0.2	1	100	No	70	No
39MW0005	11/2/2006	48	MW	ETHYLBENZENE	BRL	0.12	1	20,000	No	700	No
39MW0005	11/2/2006	48	MW	M,P-XYLENE (SUM OF ISOMERS)	BRL	0.19	2	9,000	No	10,000	No
39MW0005	11/2/2006	48	MW	NAPHTHALENE	**41**	5	5	1,000	No	12	Yes
39MW0005	11/2/2006	48	MW	TOLUENE	BRL	0.11	1	50,000	No	4,100	No
39MW0005	11/2/2006	48	MW	TRICHLOROETHENE (TCE)	BRL	0.15	1	30	No	5	No
39MW0006	12/20/2011	46	MW	C5-C8 ALIPHATIC HYDROCARBONS	BRL	10	20	3,000	No	NE	NA
39MW0006	12/20/2011	46	MW	C9-C12 ALIPHATIC HYDROCARBONS	BRL	10	20	5,000	No	NE	NA
39MW402A	10/26/2005	46	MW	1,2,4-TRIMETHYLBENZENE	**200**	1.25	6.3	NE	NA	7.8	Yes

Table N-1
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Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Location	Date	Mid-Screen Elevation (ft msl)	Sampling Method[1]	VI COPC[1]	Result	DL	RL	MCP Method 1 GW-2 Standard[2] (µg/L)	VI Screening Value Exceeded?	Generic Unrestricted Groundwater Screening Value[3] (µg/L)	VI Screening Value Exceeded?
					All Units = µg/L						
39MW402A	10/26/2005	46	MW	1,3,5-TRIMETHYLBENZENE (MESITYLENE)	**140**	1.625	6.3	NE	NA	7.8	Yes
39MW402A	11/2/2006	46	MW	1,4-DICHLOROBENZENE	BRL	0.11	1	200	No	75	No
39MW402A	11/2/2006	46	MW	C11-C22 AROMATIC HYDROCARBONS	260	150	150	50,000	No	NE	NA
39MW402A	11/2/2006	46	MW	C9-C10 AROMATIC HYDROCARBONS	120	20	20	7,000	No	NE	NA
39MW402A	11/2/2006	46	MW	C9-C12 ALIPHATIC HYDROCARBONS	32	20	20	5,000	No	NE	NA
39MW402A	11/2/2006	46	MW	cis-1,2-DICHLOROETHENE	BRL	0.2	1	100	No	70	No
39MW402A	11/2/2006	46	MW	O-XYLENE (1,2-DIMETHYLBENZENE)	BRL	0.1	1	9,000	No	10,000	No
39MW402A	11/2/2006	46	MW	TRICHLOROETHENE (TCE)	BRL	0.15	1	30	No	5	No
39MW404A	10/26/2005	51	MW	1,2,4-TRIMETHYLBENZENE	BRL	0.1	0.5	NE	NA	7.8	No
39MW404A	10/26/2005	51	MW	1,3,5-TRIMETHYLBENZENE (MESITYLENE)	BRL	0.13	0.5	NE	NA	7.8	No
39MW404A	10/26/2005	51	MW	C11-C22 AROMATIC HYDROCARBONS	130	100	100	50,000	No	NE	NA
39MW404A	10/26/2005	51	MW	C5-C8 ALIPHATIC HYDROCARBONS	47	10	10	3,000	No	NE	NA
39MW404A	10/26/2005	51	MW	C9-C10 AROMATIC HYDROCARBONS	150	10	10	7,000	No	NE	NA
39MW404A	10/26/2005	51	MW	C9-C12 ALIPHATIC HYDROCARBONS	147	10	10	5,000	No	NE	NA
39MW404A	10/26/2005	51	MW	C9-C18 ALIPHATIC HYDROCARBONS	BRL	36	100	5,000	No	NE	NA
39MW404A	10/26/2005	51	MW	cis-1,2-DICHLOROETHENE	1	0.15	0.5	100	No	70	No
39MW404A	10/26/2005	51	MW	ETHYLBENZENE	BRL	0.1	0.5	20,000	No	700	No
39MW404A	10/26/2005	51	MW	TRICHLOROETHENE (TCE)	BRL	0.1	0.5	30	No	5	No
39MW405A	10/27/2005	46	MW	C11-C22 AROMATIC HYDROCARBONS	134	100	100	50,000	No	NE	NA
39MW405A	10/27/2005	46	MW	C9-C12 ALIPHATIC HYDROCARBONS	128	10	10	5,000	No	NE	NA
39MW405A	10/27/2005	46	MW	cis-1,2-DICHLOROETHENE	BRL	0.15	0.5	100	No	70	No
39MW405A	10/27/2005	46	MW	TRICHLOROETHENE (TCE)	BRL	0.1	0.5	30	No	5	No
39MW407A	11/2/2006	39	MW	1,2,4-TRIMETHYLBENZENE	2	0.09	1	NE	NA	7.8	No
39MW407A	11/2/2006	39	MW	1,3,5-TRIMETHYLBENZENE (MESITYLENE)	BRL	0.07	1	NE	NA	7.8	No
39MW407A	11/2/2006	39	MW	ETHYLBENZENE	BRL	0.12	1	20,000	No	700	No
39MW407A	11/2/2006	39	MW	M,P-XYLENE (SUM OF ISOMERS)	3	0.19	2	9,000	No	10,000	No
39MW407A	11/2/2006	39	MW	O-XYLENE (1,2-DIMETHYLBENZENE)	BRL	0.1	1	9,000	No	10,000	No
39MW408A	10/26/2005	45	MW	1,2,4-TRIMETHYLBENZENE	**28**	0.5	2.5	NE	NA	7.8	Yes
39MW408A	10/26/2005	45	MW	1,3,5-TRIMETHYLBENZENE (MESITYLENE)	**42**	0.65	2.5	NE	NA	7.8	Yes
39MW408A	10/26/2005	45	MW	2-METHYLNAPHTHALENE	11	5	5	2,000	No	12	No
39MW408A	10/26/2005	45	MW	C11-C22 AROMATIC HYDROCARBONS	BRL	74	100	50,000	No	NE	NA
39MW408A	10/26/2005	45	MW	C5-C8 ALIPHATIC HYDROCARBONS	1,230	10	10	3,000	No	NE	NA
39MW408A	10/26/2005	45	MW	C9-C10 AROMATIC HYDROCARBONS	433	10	10	7,000	No	NE	NA
39MW408A	10/26/2005	45	MW	C9-C12 ALIPHATIC HYDROCARBONS	569	10	10	5,000	No	NE	NA
39MW408A	10/26/2005	45	MW	C9-C18 ALIPHATIC HYDROCARBONS	219	100	100	5,000	No	NE	NA
39MW408A	10/26/2005	45	MW	ETHYLBENZENE	103	1	1	20,000	No	700	No
39MW408A	10/26/2005	45	MW	M,P-XYLENE (SUM OF ISOMERS)	42	1	1	9,000	No	10,000	No
39MW408A	10/26/2005	45	MW	NAPHTHALENE	**29**	1	1	1,000	No	12	Yes
39MW408A	10/26/2005	45	MW	TOLUENE	1	1	1	50,000	No	4,100	No
39MW409A	10/26/2005	48	MW	1,2,4-TRIMETHYLBENZENE	**36**	0.2	1	NE	NA	7.8	Yes
39MW409A	10/26/2005	48	MW	1,3,5-TRIMETHYLBENZENE (MESITYLENE)	**20**	0.13	0.5	NE	NA	7.8	Yes
39MW409A	10/26/2005	48	MW	2-METHYLNAPHTHALENE	**23**	5	5	2,000	No	12	Yes
39MW409A	10/26/2005	48	MW	C11-C22 AROMATIC HYDROCARBONS	164	100	100	50,000	No	NE	NA
39MW409A	10/26/2005	48	MW	C5-C8 ALIPHATIC HYDROCARBONS	304	10	10	3,000	No	NE	NA
39MW409A	10/26/2005	48	MW	C9-C10 AROMATIC HYDROCARBONS	377	10	10	7,000	No	NE	NA

Table N-1
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Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

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					All Units = µg/L						
39MW409A	10/26/2005	48	MW	C9-C12 ALIPHATIC HYDROCARBONS	328	10	10	5,000	No	NE	NA
39MW409A	10/26/2005	48	MW	C9-C18 ALIPHATIC HYDROCARBONS	BRL	98	100	5,000	No	NE	NA
39MW409A	10/26/2005	48	MW	ETHYLBENZENE	2	0.1	0.5	20,000	No	700	No
39MW409A	10/26/2005	48	MW	M,P-XYLENE (SUM OF ISOMERS)	BRL	0.2	1	9,000	No	10,000	No
39MW409A	10/26/2005	48	MW	NAPHTHALENE	8	1	1	1,000	No	12	No
39MW409A	10/26/2005	48	MW	TRICHLOROETHENE (TCE)	BRL	0.1	0.5	30	No	5	No
39MW409A	10/26/2005	48	MW	XYLENES, TOTAL	1	0.1	0.5	9,000	No	10,000	No
39MW410A	12/20/2011	47	MW	1,2,4-TRIMETHYLBENZENE	**24**	0.22	1	NE	NA	7.8	Yes
39MW410A	12/20/2011	47	MW	1,3,5-TRIMETHYLBENZENE (MESITYLENE)	**13**	0.2	1	NE	NA	7.8	Yes
39MW410A	12/20/2011	47	MW	2-METHYLNAPHTHALENE	4	0.1	0.2	2,000	No	12	No
39MW410A	12/20/2011	47	MW	C11-C22 AROMATIC HYDROCARBONS	262	75	150	50,000	No	NE	NA
39MW410A	12/20/2011	47	MW	C5-C8 ALIPHATIC HYDROCARBONS	104	10	20	3,000	No	NE	NA
39MW410A	12/20/2011	47	MW	C9-C10 AROMATIC HYDROCARBONS	350	10	20	7,000	No	NE	NA
39MW410A	12/20/2011	47	MW	C9-C12 ALIPHATIC HYDROCARBONS	379	10	20	5,000	No	NE	NA
39MW410A	12/20/2011	47	MW	C9-C18 ALIPHATIC HYDROCARBONS	BRL	100	200	5,000	No	NE	NA
39MW410A	12/20/2011	47	MW	cis-1,2-DICHLOROETHENE	1	0.2	1	100	No	70	No
39MW410A	12/20/2011	47	MW	ETHYLBENZENE	1	1	1	20,000	No	700	No
39MW410A	12/20/2011	47	MW	M,P-XYLENE (SUM OF ISOMERS)	BRL	0.4	1	9,000	No	10,000	No
39MW410A	12/20/2011	47	MW	NAPHTHALENE	9	0.1	0.2	1,000	No	12	No
39MW410A	12/20/2011	47	MW	TRICHLOROETHENE (TCE)	BRL	0.2	1	30	No	5	No
39MW411A	11/2/2006	45	MW	1,2,4-TRIMETHYLBENZENE	BRL	0.09	1	NE	NA	7.8	No
39MW411A	11/2/2006	45	MW	C11-C22 AROMATIC HYDROCARBONS	170	170	170	50,000	No	NE	NA
39MW411A	11/2/2006	45	MW	C5-C8 ALIPHATIC HYDROCARBONS	24	20	20	3,000	No	NE	NA
39MW411A	11/2/2006	45	MW	C9-C10 AROMATIC HYDROCARBONS	73	20	20	7,000	No	NE	NA
39MW411A	11/2/2006	45	MW	C9-C12 ALIPHATIC HYDROCARBONS	32	20	20	5,000	No	NE	NA
39MW411A	11/2/2006	45	MW	cis-1,2-DICHLOROETHENE	BRL	0.2	1	100	No	70	No
39MW411A	11/2/2006	45	MW	ETHYLBENZENE	2	0.12	1	20,000	No	700	No
39MW411A	11/2/2006	45	MW	O-XYLENE (1,2-DIMETHYLBENZENE)	BRL	0.1	1	9,000	No	10,000	No
39MW411A	11/2/2006	45	MW	TRICHLOROETHENE (TCE)	BRL	0.15	1	30	No	5	No
91MW0313B	2/11/2003	54	MW	ETHYLBENZENE	5.15	0.178	1	20,000	No	700	No
SD-5 South Area											
00MW0524E	8/4/1997	41	MW	No VI COPCs detected	ND	--	--	--	--	--	--
00MW0526X	1/15/1999	5	MW	No VI COPCs detected	ND	--	--	--	--	--	--
28DP0001	1/27/2004	38	VP	No VI COPCs detected	ND	--	--	--	--	--	--
28DP0001	1/27/2004	28	VP	No VI COPCs detected	ND	--	--	--	--	--	--
28DP0001	1/27/2004	18	VP	No VI COPCs detected	ND	--	--	--	--	--	--
28DP0001	1/27/2004	8	VP	No VI COPCs detected	ND	--	--	--	--	--	--
28DP0001	1/27/2004	-2	VP	No VI COPCs detected	ND	--	--	--	--	--	--
28DP0001	1/28/2004	-12	VP	No VI COPCs detected	ND	--	--	--	--	--	--
28DP0002	1/27/2004	36	VP	No VI COPCs detected	ND	--	--	--	--	--	--
28DP0002	1/27/2004	26	VP	No VI COPCs detected	ND	--	--	--	--	--	--
28DP0002	1/27/2004	16	VP	No VI COPCs detected	ND	--	--	--	--	--	--
28DP0002	1/27/2004	6	VP	No VI COPCs detected	ND	--	--	--	--	--	--
28DP0002	1/27/2004	-4	VP	No VI COPCs detected	ND	--	--	--	--	--	--
28DP0002	1/27/2004	-14	VP	No VI COPCs detected	ND	--	--	--	--	--	--

Table N-1
Comparison of VI COPC Concentrations in SD-5 and Vicinity Groundwater
to Applicable Groundwater-to-Indoor Air Screening Values
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Location	Date	Mid-Screen Elevation (ft msl)	Sampling Method[1]	VI COPC[1]	Result	DL	RL	MCP Method 1 GW-2 Standard[2] (µg/L)	VI Screening Value Exceeded?	Generic Unrestricted Groundwater Screening Value[3] (µg/L)	VI Screening Value Exceeded?
					All Units = µg/L						
28DP0002	1/28/2004	-24	VP	No VI COPCs detected	ND	--	--	--	--	--	--
28DP0002	1/28/2004	-34	VP	No VI COPCs detected	ND	--	--	--	--	--	--
28MW0032B	3/14/2002	-8	MW	No VI COPCs detected	ND	--	--	--	--	--	--
28MW0032C	1/26/1999	16	MW	No VI COPCs detected	ND	--	--	--	--	--	--
91MW0522C	11/21/2000	14	MW	No VI COPCs detected	ND	--	--	--	--	--	--
91MW0522D	7/19/1999	40	MW	No VI COPCs detected	ND	--	--	--	--	--	--
ECMWJNP01M	6/25/2001	-16	MW	No VI COPCs detected	ND	--	--	--	--	--	--
ECMWJNP01S	6/25/2001	9	MW	No VI COPCs detected	ND	--	--	--	--	--	--

Data Source: AFCEE, June 2012, MMR-AFCEE Data Warehouse

Notes:

1. All locations sampled for VOCs by EPA Method 8260B and/or EPH/VPH by MassDEP Method.

2. 310 CMR 40.0974(2) http://www.mass.gov/dep/cleanup/laws/0974_2.htm.

3. EPA, 2002, Draft Guidance for Evaluating the VI to Indoor Air Pathway from Groundwater and Soils http://www.epa.gov/osw/hazard/correctiveaction/eis/vapor/complete.pdf, using target risk levels of $1x10^{-6}$ excess lifetime cancer risk and noncancer hazard quotient of 0.1 in accordance with best practices for vapor intrusion screening to account for cumulative effects from multiple chemicals. Values updated by CH2M HILL based on May 2012 Regional Screening Levels (Residential Indoor Air) for Chemical Contaminants at Superfund Sites http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm.

Shaded rows represent the SD-5-related VI COPCs TCE and PCE. Other primarily petroleum related VI COPCs included in this table are attributable to the PFSA- and FTA-2 sites and have been included for completeness. Refer to Appendices O and P for the VI evaluations for FTA-2 and PFSA.

-- = not applicable, no detections were reported for this sample.

Screening values shown (both the MassDEP MCP Method 1 Groundwater-2 screening values and generic unrestricted groundwater screening values) are summarized in Table 4-1 of the main document.

Results in bold exceed a VI screening value.

Key:

BRL = below reporting limit
DL = detection limit
EPA = U.S. Environmental Protection Agency
EPH = extractable petroleum hydrocarbons
ft msl = feet mean sea level
GW-2 = MCP Method 1 GW-2 groundwater standard
J = estimated concentration
MCP = Massachusetts Contingency Plan
MassDEP = Massachusetts Department of Environmental Protection
MW = monitoring well sample
NE = not established
RL = reporting limit
VI COPC = Vapor Intrusion Contaminant of Potential Concern
VOC = volatile organic compound
VPH = volatile petroleum hydrocarbon
VP = vertical profile sample
µg/L = micrograms per liter

Table N-2
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Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Location	Northing (ft)	Easting (ft)	Surface Elevation (ft msl)	Measuring Point Elevation (ft msl)	Total Well Depth (ft bgs)	Top Screen Depth (ft bgs)	Bottom Screen Depth (ft bgs)	Top Screen Elevation (ft msl)	Bottom Screen Elevation (ft msl)	Screen Length (ft)
SD-5 North Area										
05MW0001	237957	863373	109.09	111.58	67	56.50	66.50	52.59	42.59	10
05MW0002	238584	863658	110.41	112.82	63	53.00	63.00	57.41	47.41	10
24MW0304A	236309	865403	104	106.70	62	52.00	62.00	52.30	42.30	10
24MW401A	236108	865388	105	103.65	62	52.00	62.00	52.52	42.52	10
24MW402A	236074	865494	103	101.78	62	52.00	62.00	50.52	40.52	10
24MW403A	236166	865519	101	100.78	62	52.00	62.00	49.47	39.47	10
24MW404A	236289	865481	103	102.37	64	54.00	64.00	49.34	39.34	10
24MW406A	236179	865346	104	102.99	62	52.00	62.00	51.91	41.91	10
24MW407A	236152	865460	104	102.80	62	52.00	62.00	51.63	41.63	10
24MW408A	235895	865724	85	83.90	42	32.00	42.00	52.65	42.65	10
24MW409A	235877	865807	93	92.35	52	42.00	52.00	51.09	41.09	10
24MW410A	236011	865812	90	89.09	52	42.00	52.00	47.92	37.92	10
24MW411A	236319	865800	104	103.44	64	54.00	64.00	50.14	40.14	10
24MW412A	236065	865710	89	87.75	52	42.00	52.00	46.73	36.73	10
24MW413A	236221	865601	102	101.48	64	54.00	64.00	48.39	38.39	10
24MW414A	236048	865577	99	98.55	62	52.00	62.00	47.35	37.35	10
24MW415A	235968	865615	94	93.43	54	44.00	54.00	50.13	40.13	10
24MW416A	235825	865694	82	80.85	42	32.00	42.00	49.64	39.64	10
24MW417A	236169	865696	102	100.93	64	54.00	64.00	47.79	37.79	10
24MW421A	235953	865480	102	100.95	62	52.00	62.00	49.78	39.78	10
24MW422A	236328	865386	105	103.72	60	50.00	60.00	54.58	44.58	10
28BH0576*	236025	865683	87	NA	NA	NA	NA	NA	NA	NA
28BH0581	236322	864910	104	NA	NA	NA	NA	NA	NA	NA
28BH0582*	236240	864679	104	NA	NA	NA	NA	NA	NA	NA
28MW0004	239586	864723	111.76	114.20	62	52.00	62.00	59.76	49.76	10
28MW0005	239249	864218	108.66	111.50	61	51.00	61.00	57.66	47.66	10
28MW0006	239034	864807	109.25	111.71	64	51.80	61.80	57.45	47.45	10
28MW0009	239768	864763	111.89	114.62	64	53.50	63.50	58.39	48.39	10
28MW0010	239848	864939	114.53	117.66	66	56.00	66.00	58.53	48.53	10
28MW0010	239848	864939	114.53	117.66	66	56	66	58.53	48.53	10
28MW0011	239333	864878	110.90	113.44	63	53.00	63.00	57.90	47.90	10
28MW0013	239327	864946	112.07	115.14	63	53.00	63.00	59.07	49.07	10
28MW0014	239115	864619	96.08	98.92	49	44.00	49.00	52.08	47.08	5
28MW0016	238623	864062	96.79	99.42	50	40.00	50.00	56.79	46.79	10
28MW0017	238467	864422	99.38	102.34	53	43.00	53.00	56.38	46.38	10
28MW0019A	236346	864874	104	107.06	79	74.00	79.00	29.90	24.90	5

Table N-2
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Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Location	Northing (ft)	Easting (ft)	Surface Elevation (ft msl)	Measuring Point Elevation (ft msl)	Total Well Depth (ft bgs)	Top Screen Depth (ft bgs)	Bottom Screen Depth (ft bgs)	Top Screen Elevation (ft msl)	Bottom Screen Elevation (ft msl)	Screen Length (ft)
28MW0022	237103	863963	97.29	100.01	60	50.00	60.00	47.29	37.29	10
28MW0023	236929	864213	104.77	107.76	66	56.00	66.00	48.77	38.77	10
28MW0101	240813	864881	110.77	110.35	59	49	59	61.77	51.77	10
28MW0102	240912	864750	111.3	110.82	62	52	62	59.30	49.30	10
28MW0104	239489	864270	110.51	112.99	62	52.00	62.00	58.51	48.51	10
28MW0105	239366	863957	111.64	113.89	63	53.00	63.00	58.64	48.64	10
28MW0106	239276	864133	109.21	111.25	61	51.00	61.00	58.21	48.21	10
28MW0574	236786	864960	106	108.04	82	77.00	82.00	29.25	24.25	5
28MW0588*	236216	865146	103	103.39	60	49.70	54.70	53.70	48.70	5
28MW0589*	236258	865109	103	103.02	60	50.00	55.00	53.20	48.20	5
28MW0590	236171	865141	103	102.97	60	49.80	54.80	53.30	48.30	5
28MW0591A*	236162	865316	104	103.62	85	80.00	85.00	23.90	18.90	5
28MW0592C	236311	864859	104	103.18	64	59.00	64.00	44.65	39.65	5
28MW0593C	236238	865051	103	103.10	64	59.00	64.00	44.37	39.37	5
28MW0594C	236155	865048	104	105.17	58	53.10	58.30	50.51	45.31	5
28MW0595C	236144	864663	104	106.39	64	59.00	64.00	44.98	39.98	5
28MW0597C	237928	865035	105.74	105.33	62	57.10	62.10	48.64	43.64	5
28MW0598B	237308	864797	107.16	106.90	62	57.00	62.00	50.16	45.16	5
28MW0903	239722	864983	113.9	113.55	62	52	62	61.90	51.90	10
28PZ0583*	236242	865142	103	103.19	118	88.20	118.20	15.20	-14.80	30
28PZ0584*	236254	865062	103	103.15	118	88.20	118.20	15.20	-14.80	30
28PZ0585	236171	865147	103	103.04	118	88.20	118.20	15.00	-15.00	30
39DP0101	238916	864296	103	NA	NA	NA	NA	NA	NA	NA
39DP0102	237278	864112	96	NA	NA	NA	NA	NA	NA	NA
39DP0103	236790	864212	102	NA	NA	NA	NA	NA	NA	NA
39MW0001	237916	863979	94.20	96.99	47	37.40	47.40	56.80	46.80	10
39MW0002	238522	864230	98.32	100.47	56	46.10	56.10	52.22	42.22	10
39MW0003	238045	864179	94.60	97.25	50	40.00	50.00	54.60	44.60	10
39MW0004	238090	864259	95.70	98.11	46	43.10	45.50	52.60	50.20	2
39MW0005	237934	864241	98.12	100.44	50	46.00	51.00	45.67	50.67	5
39MW0006	237335	864407	105.28	104.92	60	54.80	59.80	50.48	45.48	5
39MW402A	237974	864296	95.91	94.13	50	40.00	50.00	55.91	45.91	10

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39MW404A	237862	864218	99.52	97.46	54	44.00	54.00	55.52	45.52	10
39MW405A	237836	864298	90.72	95.18	50	40.00	50.00	50.72	40.72	10
39MW407A	237992	864176	93.35	90.23	54	44.00	54.00	49.35	39.35	10
39MW408A	237979	864249	95.14	96.92	58	43.00	58.00	52.14	37.14	15
39MW409A	237869	864275	98.73	96.80	58	43.00	58.00	55.73	40.73	15
39MW410A	237777	864275	100.05	98.82	54	44.00	54.00	56.05	46.05	10
39MW411A	237794	864309	98.87	98.51	54	44.00	54.00	54.87	44.87	10
91MW0313B	236100	865537	102	104.49	59	49.00	59.00	52.50	42.50	10
SD-5 South Area										
00MW0524E	232695	865996	60	59.27	24	13.70	23.70	45.86	35.86	10
00MW0526X	232514	866388	51	50.66	48	43.00	48.00	7.90	2.90	5
28DP0001	232831	866220	72	NA	NA	NA	NA	NA	NA	NA
28DP0002	232374	866066	62	NA	NA	NA	NA	NA	NA	NA
28MW0032B	233697	865133	94	93.69	105	100.00	105.00	-5.92	-10.92	5
28MW0032C	233712	865130	94	93.73	81	75.00	80.00	18.98	13.98	5
91MW0522C	234009	864830	50	49.42	38	33.00	38.00	16.74	11.74	5
91MW0522D	234013	864828	50	49.37	12	7.00	12.00	42.72	37.72	5
ECMWJNP01M	232421	866551	36	36.00	55	49.60	54.60	-13.50	-18.50	5
ECMWJNP01S	232421	866551	36	36.00	30	24.50	29.50	11.60	6.60	5

Data Source: AFCEE, June 2012, MMR-AFCEE Data Warehouse

Key:

bgs = below ground surface

ft = feet

msl = mean sea level

NA = Not Applicable - locations are direct push vertical profile borings and have no permanent screens.

* = This table contains well construction information for permanent monitoring wells. However, additional groundwater profile data was collected at these locations. Refer to Table N-1.

APPENDIX O

PFSA Vapor Intrusion Evaluation

TABLE OF CONTENTS

Figures

Tables

ACRONYMS AND ABBREVIATIONS

AST	aboveground storage tank
AVGAS	aviation gasoline
bgs	below ground surface
BSVR	biosparging/vapor recovery
BTEX	benzene, toluene, ethylbenzene, xylenes
COC	contaminant of concern
COPC	contaminant of potential concern
CS	Chemical Spill
CSM	conceptual site model
CVOC	chlorinated volatile organic compound
EPA	U.S. Environmental Protection Agency
FS	Fuel Spill
ft	feet/foot
H_2O_2	hydrogen peroxide
JP-4	Jet Propellant-4
$KMnO_4$	potassium permanganate
MassDEP	Massachusetts Department of Environmental Protection
MCP	Massachusetts Contingency Plan
MMR	Massachusetts Military Reservation
MOGAS	motor gasoline
NaClO	sodium hypochlorite
NaOH	sodium hydroxide
OWS	oil-water separator
O&M	operations and maintenance

ACRONYMS AND ABBREVIATIONS

PCE	tetrachloroethene
PFSA	Petroleum Fuel Storage Area
PVC	polyvinyl chloride
SD	Storm Drain
RI	remedial investigation
SRTF	Sandwich Road Treatment Facility
SVE	soil vapor extraction
SVOC	semivolatile organic compound
1,2,4-TMB	1,2,4-trimethylbenzene
1,3,5-TMB	1,3,5-trimethylbenzene
TCE	trichloroethene
UST	underground storage tank
VI	vapor intrusion
VOC	volatile organic compound

O1.0 CONCEPTUAL SITE MODEL

The Petroleum Fuel Storage Area (PFSA), located on the north side of South Outer Road (Figure O-1), has served as the main fuel delivery and distribution area for the flightline since the early 1950s. It was the primary storage and distribution center for Jet Propellant-4 (JP-4), aviation gasoline (AVGAS), motor gasoline (MOGAS, automotive gasoline), and No. 2 fuel oil for the Massachusetts Military Reservation (MMR) until 2009. The PFSA is located inside the fenced flightline security area.

Elements of this conceptual site model (CSM) include a physical description of the PFSA and vicinity (including infrastructure, operations, and geology/hydrogeology), followed by a chronology of petroleum releases and the site assessment and remediation activities taken to address them, including information on the nature and extent of contamination. Finally, buildings and utilities that are currently (or were formerly) at or near the PFSA are described. It is noted that historical documents sometimes contradicted one another with regard to minor details such as the number designations of the tanks, buildings, and other structures that have changed over time. The latest number designations for these features from the mid-1990s are used throughout this appendix.

O1.1 DESCRIPTION OF PFSA AND VICINITY

The PFSA site is located on the southeast corner of the MMR in Mashpee, Massachusetts (Figure 1-2 of the main document). The PFSA infrastructure (now demolished) occupied approximately five acres of relatively flat terrain at the head of the Storm Drain-2 (SD-2) drainage ditch that runs to the south, south of South Outer Road (Figure O-2). Features of the PFSA and vicinity are shown on Figure O-1, and additional historical features, such as the location of former tanks and buildings, are shown on Figure O-2. A schematic cross-section showing the vapor intrusion (VI) CSM for the PFSA is presented in Figure 4-4 of the main document.

The PFSA consisted of two pump house buildings (Buildings 170 and 172/173), fuel unloading racks, three aboveground storage tanks (ASTs), Tanks 21, 23, and 24, and

underground fuel distribution lines (Figure O-2). It is noted that over the years, the pump house buildings were replaced and reconfigured while the building numbers were retained; therefore, the historical figures may show differing locations of the numbered buildings. ASTs 21, 23, and 24 had capacities of 500,000, 500,000, and 1,200,000 gallons, respectively, and were surrounded by containment berms made of native sand coated with asphalt. The ground within the berms was lined with coarse gravel over fine- to medium-grained sand, while the area outside the berms was a combination of paved and grassy areas (ABB-ES 1996). The remaining PFSA structures were demolished in 2010/2011, and the PFSA is now largely a grassed area, although some paved areas remain. When Tank 23 was removed, soil borings were advanced in the bermed area around the tank and a 1.0- to 1.5-foot thick layer of clay was encountered at a depth of approximately 1.5 to 2.0 feet (ft) below ground surface (bgs) (HWG 2011).

Historically, fuel received or stored at the PFSA was transferred through underground pipelines to fuel distribution pump houses located on the western side of the aircraft maintenance ramp, or to the distribution pump house at the eastern end of the flightline. From 1955 to 1965, AVGAS and JP-4 were delivered to the PFSA from the railroad fuel pumping station at MMR, located at the source for the Fuel Spill-2 (FS-2) site. FS-2 is located approximately 9,500 ft west of PFSA near the intersection of Kittridge and Turpentine roads (AFCEE 2008a). From 1965 to 1973, AVGAS and JP-4 were delivered to MMR through a 3-inch-diameter underground pipeline extending from the Cape Cod Canal at Sandwich to the PFSA. Fuels were subsequently delivered by truck to the PFSA and then distributed by truck to aircraft or other points of use (ABB-ES 1996).

Tanks 23 and 24 were constructed with floating lids, allowing rainwater and condensation to enter and migrate to the bottom of each of the tanks. This water was reportedly removed from the tank bottoms by opening drain valves and discharging the accumulated water to the containment berms until fuel product discharge was observed. The floating lids were replaced at ASTs 23 and 24 with solid lids in 1977 and 1988, respectively.

Discharges from the AST containment berms and paved surfaces at fuel unloading areas typically entered storm drain catch basins via asphalt-lined ditches and then may have exited to the MMR storm water sewer system and then ultimately to the oil-water separator (OWS) located on the southeast side of South Outer Road. The OWS discharged to a drainage ditch (SD-2) (Figure O-2) which lies south of the far eastern portion of MMR (Figure 1-2 of the main document). Two 42-inch-diameter storm drains and the OWS discharged to the upstream end of SD-2 until their removal in 2002 (AFCEE 2008a).

Floor drains in the Building 170 and 172/173 pump houses formerly discharged to two nearby French drains that were replaced in 1989 with a 2,000-gallon underground storage tank (UST) located east of the buildings. Fuel-contaminated water was historically discharged from fuel/water separator equipment in both pump houses (Buildings 170 and 172/173) to the floor drains when filters in the separators were changed. A sanitary waste cesspool was also located near the pump house buildings to the east (Figure O-2).

The Building 174 pump house was located immediately north of the PFSA (Figure O-2). Four 50,000-gallon USTs were installed adjacent to Building 174 in 1956 that were used to dispense AVGAS (that was received from the PFSA) via an underground pipeline to aircraft on the maintenance ramp. Floor drains in Building 174 discharged to a 2,000-gallon collection UST northwest of the ASTs that was also installed in 1956. The fuel line from the PFSA to these USTs was abandoned in the early 1970s, and the five USTs were removed in 1994 (ABB-ES 1996, AFCEE 2008a).

Surface soils consist of sandy topsoil over silty fine- to coarse-grained sand or medium- to coarse-grained sand extending to approximately 4 ft bgs. Subsurface soils are predominantly well-graded medium-grained sand with small amounts of fine- to coarse-grained sand, and traces of fine- to coarse-grained gravel, cobbles, and silt. Soils at the PFSA are characteristic of typical glacial outwash comprising the Mashpee Pitted Plain (AFCEE 2003).

The depth to groundwater varies spatially and temporally but is approximately 45 to 50 ft bgs throughout the PFSA site. The PFSA site is approximately 3,800 ft north of Johns Pond (Figure 1-2 of main document), and groundwater flows from the PFSA in a south-southeast direction towards the northwest corner of the pond under a hydraulic gradient of approximately 0.0022. A U.S. Geological Survey pumping test estimated the hydraulic conductivity of the shallow portion of the aquifer at 380 ft per day; assuming a porosity of 0.3, groundwater flow velocities in the shallow portion of the aquifer in this area are estimated at 2 to 3 ft per day (AFCEE 2003).

O1.2 PETROLEUM RELEASE, SITE ASSESSMENT, AND REMEDIATION CHRONOLOGY

The following summarizes the history of releases not related to the routine operations at PFSA (e.g., release of petroleum contaminated water/product during the draining of water from the ASTs), as well as site assessment and remediation activities conducted at the PFSA (ABB-ES 1996; ABB-ES 1997; AFCEE 2008a).

- 1960s: A 2,000-gallon jet fuel spill in the Building 170 pump house likely discharged to one of two French drains or was washed to the storm sewer discharging to SD-2; this release is referred to as Fuel Spill-10 (FS-10). In addition, a 2,000-gallon jet fuel release occurred into the Tank 21 containment berm due to an overfill and likely infiltrated the ground; this release was described as FS-11.
- 1985: A Phase II confirmation and quantification study (R.F. Weston, Inc. 1985) detected fuel-related volatile organic compounds (VOCs) in groundwater hydraulically downgradient (i.e., south) of the PFSA.
- 1986: Field investigations (E.C. Jordan Co. 1988) found benzene, toluene, ethylbenzene, xylenes (BTEX), related semivolatile organic compounds (SVOCs), and elevated concentrations of inorganics in soil samples collected from within the bermed areas of the ASTs.
- 1987-1988: The “Mashpee Groundwater Study” (E.C. Jordan 1990) found soil contamination in a boring south of the PFSA near the SD-2 OWS and also detected numerous fuel-related tentatively identified compounds in groundwater. A subsequent work phase showed significant concentrations of BTEX, related SVOCs, and metals in near-surface soil samples and at the water table in the AST area and identified a fuel-contaminated plume migrating at least 1,200 ft offsite in groundwater.
- 1989: The two French drains near Buildings 170 and 172/173 were excavated and 10 cubic yards of contaminated soil were removed. Other contaminated soil was left

in place. A 2,000-gallon waste collection UST was installed nearby to replace the French drains. This UST was later removed (ANG 2011).

- 1989-1990: A remedial investigation (RI) was conducted to characterize the nature and extent of sediment, deep soil, and groundwater contamination. Soil contamination at the capillary fringe was identified as a continuing source of contaminants to groundwater (ABB-ES 1997).
- 1993-1994: The fuel distribution lines were upgraded from underground to aboveground and during this process a total of 11 cubic yards of fuel-contaminated soil was excavated. Six- and 8-inch-diameter underground fuel distribution lines between Buildings 170 and 172/173 and the three ASTs were removed, as were valve boxes serving the three ASTs and a 10-inch-diameter corrugated metal drain pipe at Building 172/173. Two cubic yards of contaminated soil were removed in conjunction with the Tank 21 valve box removal (located inside the containment berm); however, some petroleum-contaminated soil remained. Petroleum-contaminated soil was also encountered during removal of the pipeline between Tank 23 and its valve box and during removal of the corrugated metal drain pipe at Building 172/173. Four cubic yards of soil were removed; however, some contaminated soil remained. Finally, Buildings 170 and 173 associated with the PFSA at that time were demolished to the ground surface, leaving the foundations in place. (Several similarly numbered buildings were subsequently constructed in this general location. All buildings in this area were later demolished in 2010/2011.)
- 1994: A supplemental RI was conducted to further characterize groundwater contamination and evaluate site risks (ABB-ES 1994). Johns Pond was identified as the primary discharge point for groundwater migrating from the PFSA.
- 1996: Heavy rain and a pump failure at the PFSA caused 6,000 gallons of fuel-contaminated water to spill from a fuel pump house (Building 172). Of the 6,000 gallons, about 300 gallons were diesel and/or jet fuel. Because of high storm water flows, some fuel discharged to SD-2 south of the PFSA. In response to the spill, 480 cubic yards of fuel-contaminated soil was removed from the PFSA, and 120 cubic yards of fuel-contaminated soil was excavated from the SD-2 drainage ditch as part of an Immediate Response Action performed under the Massachusetts Contingency Plan (MCP). The excavated soils were transported off site to Bardon Trimount of Stoughton, Massachusetts for asphalt-batching. A soil vapor extraction (SVE) system was installed as part of the Immediate Response Action to remove the remaining localized contamination associated with the spill (AFCEE 1998). This SVE system was intended only to address the contamination north of Building 173 and should not be confused with the larger PFSA remediation system installed later and discussed in subsequent sections of this document.
- 1996: A final RI (ABB-ES 1996) was conducted to further characterize soil and groundwater contamination and evaluate site risks. The RI concluded that the highest concentrations of fuel-related groundwater contamination appeared to have originated from the area of the three ASTs (Tanks 21, 23, and 24) and the two pump houses (Buildings 170 and 172/173). It stated that fuel-related contamination leached from sources in a dissolved phase in percolating groundwater or via the downward

migration of free-product releases, creating capillary fringe soil contamination. More recent data collected since the RI indicate that the capillary fringe soil contamination is present between approximately 54 and 64 ft bgs in the western portion of the PFSA, and between approximately 38 to 58 ft bgs in the eastern portion of the PFSA. The typical depth to groundwater in the vicinity of this capillary fringe soil contamination is approximately 40 to 55 ft bgs (AFCEE 2003). The RI also indicated that most of the groundwater contamination resulted from direct leaching from capillary fringe soils. Organic chemicals in groundwater included BTEX, 2-hexanone, naphthalene, 2-methylnaphthalene, and bis(2-ethylhexyl)phthalate. Near-surface soil sampling at Tanks 21, 23, and 24 did not detect near-surface contamination at Tank 21 but did at Tanks 23 and 24; contamination was attributed to the discharge of petroleum- contaminated water and/or fuel product drained from tank bottoms and was estimated to impact a total of 2,100 cubic yards of soil. Soil sampling confirmed that the French drains at Buildings 170 and 172/173 had been sources of fuel-related contamination and also several chlorinated compounds. The total volume of fuel-contaminated soil at the capillary fringe beneath the PFSA was estimated at 69,000 cubic yards. The RI recommended a feasibility study to assess remedial options to address the shallow and deep contaminated soil.

- 1997: A focused feasibility study (ABB-ES 1997) was conducted to evaluate remedial options to address the PFSA contamination. Shallower soil contamination was determined to not pose a threat to future utility workers or to ecological receptors except in one area near the ASTs (however, subsequent additional soil sampling in this area indicated that contaminant concentrations were below applicable standards and remediation was not warranted). However, petroleum contamination at the capillary fringe was determined to be an ongoing source of contamination to groundwater that required remediation. Three alternatives were evaluated: no action, institutional controls, and biosparging with off-gas collection and treatment. The report concluded that only the biosparging alternative would achieve remedial action objectives.
- 1998: Tank 21 and its associated berm were removed (AFCEE 2003).
- 1998: Record of Decision for the PFSA (AFCEE 1998) was finalized that required biosparging with off-gas collection and treatment to remediate the PFSA contaminants of concern (COC), ethylbenzene and xylenes.
- 2001-Present: The biosparging/soil vapor recovery (BSVR) system (AFCEE 2001 and 2003) was installed and started up to address fuel contamination at the capillary fringe that was present downgradient from the three ASTs and two pump house buildings. Biosparing wells were equipped with two-foot-long screens positioned below the water table, from 58 to 60 ft bgs to 68 to 70 ft bgs. SVE wells were equipped with 10-foot-long screens positioned much shallower, above the water table, from 20 to 30 ft bgs (Table O-1). The layout of this system, which is organized into six zones and shown on Figure O-3, covers areas both north and south of South Outer Road. The OWS was demolished in 2002 prior to installation of the BSVR, a portion of which overlies the former footprint of the OWS. BSVR Zones #2 and #4 began operation in October 2001; BSVR Zones #1, #3, and #5 began operation in July 2002;

and BSVR Zone #6 began operation in May 2003. The operation of the BSVR system decreased contaminant concentrations in both soil and groundwater at the PFSA. BSVR Zones #1 and #2 were shut down in 2006 (AFCEE 2007). In February 2008 (AFCEE 2008b), AFCEE shut down the SVE portions of Zones #3, #4, #5, and #6 of the BSVR system and operated the biosparging portions of all six zones to maintain aerobic conditions to promote continued biodegradation of remaining petroleum hydrocarbons. In October 2008, biosparging at Zones #3 through #6 was stopped, and all systems were shut down in April 2010. Note that all subsurface piping is still in place and that the system has not been fully abandoned (AFCEE 2011b).

- 2010/2011: Tanks 23 and 24 and Buildings 171, 172, and 173 were removed. Contaminated soil was encountered during the dismantling of Tank 23 and 1,056 gallons of fuel oil, 550 gallons of oily water, and 760 cubic yards of oil-impacted sand were removed for offsite disposal/recycling as part of an Immediate Response Action under the MCP (HWG 2011). Excavation activities were not successful in achieving background conditions in the entire Tank 23 area, and additional site investigation was recommended to fully delineate the vertical and horizontal extent of impacted soils for possible additional remedial actions. Tank 24 was also dismantled at this time, with no evidence of significant contamination observed.

O1.3 NEARBY BUILDINGS AND THEIR USES

There are currently no buildings or other aboveground structures at the PFSA. Two buildings unrelated to the PFSA are located south of the PFSA on the south side of South Outer Road (Figure O-1): Building 561, the Sandwich Road Treatment Facility (SRTF), and Building 587, Operations and Maintenance (O&M) Building. Building 196, a hangar and maintenance building formerly located north of South Outer Road and east of the PFSA, was demolished in mid-2011. Buildings 561 and 587 are described below.

Building 561 is a metal building constructed on a slab on grade in 1997. At present, contaminated groundwater from the Chemical Spill-10 (CS-10) plume is conveyed to the SRTF where it is filtered through a greensand filter system, then treated by granular activated carbon, and returned to the aquifer via reinjection wells (AFCEE 2011b). Four of these reinjection wells, each currently injecting approximately 58 gallons per minute, are located just south of Buildings 561 and 587 (Figure O-4). The effects of reinjection appear to be minimal in terms of this VI evaluation (i.e., by creating a clean water lens) as indicated by information presented below in Section O2.1.1. Building 561 is currently occupied approximately 2 hours per week by one information technology specialist who

works on computers, and for approximately one hour per day (each) by two field staff who perform treatment plant O&M activities that include daily checks of flow meters and other devices, periodic water sampling and supervision of carbon changeouts, and facility repair as needed. Materials on hand in the building include: grease, paint, gasoline (2-stroke pre-mixed), Suzuki outboard oil (2-stroke), gas line antifreeze, motor oil, Nelson latex firestop sealant, silicone, propane, polyvinyl chloride (PVC) cleaner, Teflon dope, cleaner/etcher containing phosphoric acid, iron oxide rust remover, deoxidizing powder, 3M desk and office cleaner, windshield deicer (methyl alcohol), diesel fuel therapy (anti gelling agent), power steering fluid, smoke detector test, cement, Super Gel-X, sakrete, methanol, potassium permanganate, sulfamic acid, hydrochloric acid, sodium thiosulfate, and sodium hydroxide (AFCEE 2011c).

There is an (aboveground) chemical storage facility located to the east of the Building 561 (Figure O-4) consisting of a 4,500-gallon sodium hydroxide (NaOH) tank, a 1,000-gallon sodium hypochlorite (NaClO) tank, and a 5,000-gallon hydrogen peroxide (H_2O_2) tank. A 500-gallon potassium permanganate ($KMnO_4$) tank is located within the facility itself. $KMnO_4$ and NaOH were previously used with the greensand filters to remove iron and manganese. NaClO was used as a biocide to the effluent to control biological growth and prevent biological plugging of the reinjection wells. The H_2O_2 tank was installed to add dissolved oxygen to the effluent but was never used. Current conditions do not warrant the use of any of these chemicals. The storage tanks and associated piping for all of these chemicals are empty (AFCEE 2011b).

Building 587 is a metal building constructed on a slab on grade in 2003. This building is currently occupied approximately 8 to 10 hours per day (each) by two office workers and 2 to 3 hours per day (each) by four field staff. Activities include both office work and equipment maintenance. The building includes a field equipment office where calibration and minor repair of field monitoring equipment (e.g., gas meters, photoionization detectors) is performed. Materials on hand in the building include: gases (argon, carbon dioxide, helium, acetylene, oxygen), machine cutting oil, C-5 Anti-Seize lubricant, Fog Shield XP, OFF/Cutter/Raid insect repellent, paint, GUNK Fuel Stabilizer,

PVC primer, PVC cement, PB Blaster (penetrating oil), white lithium grease, GUNK Brake Cleaner, WD-40, spray deicer, OSO HEET Fuel Line Anti-Freeze, motor oil, antifreeze, Diesel Anti-Gel, fiber optic cleaner, lock deicer spray, DCON Pellets (mice), GUNK Contact Cleaner, CRC Battery Cleaner, power steering fluid, hydraulic jack oil, windshield washer fluid, brake fluid, and Big Puncture Seal (AFCEE 2011c). Vehicles are routinely parked in the parking lot outside of Buildings 587 and 561.

O1.4 NEARBY UTILITIES

Figure O-4 shows existing subsurface utilities and Table O-2 summarizes additional details regarding dimensions and materials of construction. Subsurface utilities from Buildings 561 and 587 connect to utility mains beneath South Outer Road and include electrical and communications conduit, natural gas, and potable water. Building 587 has a sanitary sewer line that connects to a main under South Outer Road, whereas Building 561 has a septic system and leach pit. Underground groundwater extraction piping leads to Building 561 from the northwest and enters the building from the south, and underground groundwater reinjection piping leads away from Building 561 from the south side, including to the four above-mentioned reinjection wells located just south of Buildings 561 and 587. There is additional subsurface piping from the adjacent (no longer used) chemical storage facility to Building 561.

O2.0 VAPOR INTRUSION SCREENING

The subsections that follow present the results of the VI screening evaluation using the most recent concentration data for groundwater, soil, and vapor samples in the vicinity of the PFSA. The groundwater and soil data that are described below were collected from numerous borings that have been advanced and monitoring wells that have been installed in the vicinity of the PFSA. Information on the location and construction of these borings and wells is summarized in Table O-3. Vapor samples described below were collected from BSVR system inlets from the six remediation system zones shown on Figure O-3.

O2.1 GROUNDWATER

Groundwater remediation by BSVR, as described above in Section O1.2, has reduced but not eliminated petroleum-related compounds in groundwater in the vicinity of the PFSA. Therefore, an evaluation of VI potential associated with these compounds in groundwater is presented.

O2.1.1 Step 1: Clean Water Lens

As established in Section 4.0 and depicted graphically in Figure 4-1 of the main document, the first step in evaluating the possibility of VI associated with groundwater contamination is determining whether and where a 3-ft thick clean water lens is constantly present above the contamination and is expected to remain for the foreseeable future as long as the contamination exists. If the evaluation indicates that a clean water lens is present using the criteria presented in Section 4.1.1 of the main document, it can be concluded that the groundwater-to-indoor-air VI pathway is incomplete and no further evaluation related to groundwater is required.

Due to the nature of the release history for the PFSA, as outlined in Section O1.2, for the purposes of this VI evaluation, the presence of clean water lens was evaluated by assessing the VOC data collected from PFSA monitoring wells. The locations of all the groundwater sampling points used for this VI evaluation, i.e., within approximately

1,000 ft of the former ASTs, are shown on Figure O-5. The data used to support this evaluation are presented in Table O-4.

Monitoring wells installed at the PFSA and used in this VI evaluation are screened at or near the water table. As shown in Table O-4, fuel-related VOCs were detected in samples from many of the monitoring wells; in addition, several chlorinated VOCs (CVOCs) were detected at some locations.

Therefore, based on a review of the available groundwater data, a clean water lens is not present at the PFSA site and an incomplete VI pathway cannot be ruled out; further VI evaluation (i.e., Step 2 of the groundwater VI evaluation process) is warranted.

O2.1.2 Step 2: Buildings and Preferential Airflow Pathways

Buildings 561 and 587, as well as preferential airflow pathways in the form of underground utilities, are located within 100 ft of detections of the VI contaminants of potential concern (COPCs) in groundwater at the water table, as shown in Figures O-4 and O-5, and Table O-4. Within 100 ft of Building 561, these locations include 24MW401A, 24MW402A, 24MW406A, 24MW421A, and 28MW0591A. Within 100 ft of Building 587, these locations include 28PZ0583, 28MW0588, 28MW0589, and 28MW0591A. Therefore, the proximity of Buildings 561 and 587 (and the associated underground utilities) to groundwater VI COPC detections prompts further VI evaluation (i.e., Step 3 of the groundwater VI evaluation process).

O2.1.3 Step 3: Compare Groundwater Concentrations to VI Screening Values

Table O-4 contains a summary of the latest available VI COPC concentrations detected in groundwater (sampled over a date range from 1996 to 2010) compared to the groundwater-to-indoor-air screening values specified in Table 4-1 of the main document. Locations that exceed a screening value for one or more of the VI COPCs are indicated on Figure O-5 (as red dots). Figure O-5 also shows a 100-ft zone (measured horizontally) around each of the two occupied buildings (i.e., 561 and 587). Although some of these groundwater analytical data were collected over 10 years ago, the more recent data

collected in 2010 indicate that groundwater contamination remains at the water table interface in this area. In all instances, the groundwater concentration exceedances are of the U.S. Environmental Protection Agency (EPA) VI screening values for 1,2,4-trimethylbenzene (1,2,4-TMB) and 1,3,5-trimethylbenzene (1,3,5-TMB) (which are not groundwater COCs at PFSA [AFCEE 1998]). It is noted that equivalent Massachusetts Department of Environmental Protection (MassDEP) MCP Method 1 Groundwater-2 standards have not been established for these particular VI COPCs. It is also noted that CVOC compounds tetrachloroethene (PCE) and trichloroethene (TCE) were detected in groundwater, but their concentrations were below VI screening values. PCE and TCE are groundwater COCs for the CS-10 plume, and TCE is the groundwater COC for the SD-5 plume.

In summary, VI COPC concentrations exceed a screening value at the water table within 100 ft of both Buildings 561 and 587, indicating that a VI exposure pathway may be present. However, it is noted that biodegradation of petroleum compounds in the vadose zone would likely attenuate vapor-phase hydrocarbon concentrations in transit from the capillary fringe to buildings or preferential pathways. Based on an evaluation of the groundwater media, additional evaluation, including the role of biodegradation, is needed to determine whether a significant VI risk is present at the PFSA site.

O2.2 SOIL

Remediation of near surface and capillary fringe soil contamination, as described above in Section O1.2, has decreased but not eliminated soil contaminant concentrations at the PFSA. As explained in the main document, there are no screening values for soil concentrations that may be used to screen out VI potential. Therefore, detections of volatile compounds in soil (of any magnitude) within 100 ft (in any direction) of an occupied building or preferential airflow pathway has been adopted as the screening criteria to determine whether further evaluation of VI risk may be warranted. In keeping with this approach, Figure O-6 depicts soil borings with and without detections of volatile compounds in samples collected at or near the water table and also shows the 100-ft zone around Buildings 561 and 587. This information is presented in tabular form in

Table O-5, and volatile compound concentrations detected within 100 ft of Buildings 561 and 587, along with sample depths, are presented in Table O-6 (although the magnitude of the compound concentrations did not enter into decision-making, as noted above). It is also noted that the presence of soil contamination at the capillary fringe is a further line of evidence suggesting that a clean water lens is not present at the water table. Figure O-6 shows that detections of volatile compounds in soil are present at 18 borings within 100 ft of Building 561 and at one boring within 100 ft of Building 587. Detections of volatile compounds in soil are also present within 100 ft of preferential airflow pathways (as defined in the main document) at the PFSA (i.e., utilities beneath South Outer Road and leading from South Outer Road to Buildings 561 and 587 as depicted on Figure O-4). Soil sample results from below the water table are included in order to account for the potential for these samples to be exposed at times when the water table drops during periods of low rainfall and/or drought. Historic water table elevation data suggests that this possibility does exist in the vicinity of the PFSA. For contaminated soils that remain beneath the water table at all times, their VI-related impacts would be accounted for through the groundwater screening evaluation, as discussed in Section O2.1.

In summary, volatile compounds in soil are present within 100 ft of buildings and preferential airflow pathways at the PFSA site, thereby prompting the need for additional VI evaluation.

O2.3 VAPOR

As part of the BSVR remediation system operation described above in Section O1.2, samples of the vapor influent were collected quarterly from each of the six treatment zones to track remediation progress. Samples were collected in Summa canisters and laboratory analyzed by EPA Method TO-15. Details regarding the EPA Method TO-15 analytical approach and full analyte list are included in the Installation Restoration Program's Quality Assurance Project Plan (AFCEE 2011a). Table O-7 presents a summary of vapor concentration data for detected compounds for the last four quarters of BSVR operation for each of the six remediation zones. Note that Zones #1 and #2 were

shut down in 2006 (AFCEE 2007), while the other four zones operated until 2008 (AFCEE 2008b). In addition, Zones #1 and #2 were not operating in the first quarter of 2005, thus no vapor concentration data are available for this time period.

The BSVR system is located south of the former ASTs and north and east of Building 561. Six of 10 Zone #2 biosparging wells and three of five Zone #2 soil vapor extraction wells are within 100 ft of Building 561 (Figure O-3), and all of the Zone #2 biosparging and soil vapor extraction wells are within 100 ft of subsurface utility connections leading to Building 561 (Figures O-3 and O-4). The other five zones are more than 100 ft away from Building 561 and its utility connections. All six zones are more than 100 ft away from Building 587 and its utility connections.

As shown in Table O-7, petroleum-related and chlorinated compounds, as well as non-chlorinated solvent compounds, were detected in vapor samples collected from the BSVR system Zone #2 influent stream. Site remediation primarily targeted petroleum hydrocarbons, while vapor sample data collected during the operation of the BSVR system indicate that CVOCs (including PCE and other non-petroleum-related compounds) were also present in the subsurface. The source of the CVOCs detected in the BSVR influent has not been determined; however, the SD-5 North groundwater plume was present in this area as recently as 2002 (AFCEE 2008a). The primary COC in the SD-5 North plume was TCE but concentrations of PCE were oftentimes detected in the groundwater plume (AFCEE 2004). It is noted that the vapor data collected from the BSVR influent stream are at least three years old and have no quantitative value for the assessment of VI risk in this evaluation for the following reasons:

1) The vapor samples were collected from the influent stream during active venting through the operation of the BSVR system and thus would not necessarily be representative of subsurface soil gas concentrations in the absence of active venting.

2) Subsurface vapor concentrations attenuate when they intrude into a building due to dilution with indoor air, typically by one or more orders of magnitude (EPA 2002).

3) The vapor samples were collected from locations north and east of the buildings of concern (Buildings 561 and 587) rather than from beneath the buildings.

4) The vapor samples were collected from much deeper (20 to 30 ft bgs) (AFCEE 2001) than the building slabs.

However, these vapor concentration data provide another line of evidence pointing to the need for further VI evaluation near the PFSA in addition to the lines of evidence provided by the groundwater and soil evaluations described above. This is because the BSVR vapor data indicate that petroleum-related, chlorinated, and non-chlorinated solvent volatile chemicals were recently present in soil gas within 100 ft of preferential airflow pathways (see Section 4.1.2 of the main document) and possibly Building 561.

O3.0 CONCLUSIONS AND RECOMMENDATIONS

O3.1 CONCLUSIONS

Although surface and subsurface PFSA infrastructure have been removed or abandoned in place and several remedial actions have been implemented, residual soil and groundwater contamination remains at the PFSA. Groundwater contaminant concentrations have decreased due to operation of the BSVR system as well as through the processes of natural attenuation. However, based on a review of groundwater data collected as recently 2010, VI COPCs, specifically 1,2,4-TMB and 1,3,5-TMB, are present at the water table at concentrations above groundwater-to-indoor-air VI screening values. Petroleum hydrocarbons are known to readily biodegrade under aerobic conditions, including in the unsaturated zone (the design basis for the BSVR system). Therefore, it is expected that biodegradation would decrease vapor-phase petroleum hydrocarbon concentrations in transit vertically from the capillary fringe to the Building 561 and 587 slabs, and also in transit laterally from near surface contamination to the buildings. However, based on experience at other sites, significant biodegradation of CVOCs is not expected.

Contaminated near-surface soil has been addressed through excavation in several areas and SVE in one area to mitigate risks of dermal exposure to utility workers. Deeper contaminated soil at the capillary fringe has been remediated by BSVR to reduce this potential continuing source of groundwater contamination. Detectable concentrations of volatile petroleum hydrocarbon-related compounds remain in soil. Remediation was undertaken before VI became an issue in the site assessment and remediation industry; therefore, it is not clear if the soil contamination has been addressed sufficiently to mitigate VI risk.

In summary, while remediation has substantially improved site conditions, remedial actions were not designed to address VI risks, and VI risks cannot be ruled out based on this VI screening evaluation for the following primary reasons:

- Groundwater contaminant concentrations exceed groundwater-to-indoor-air VI screening values within approximately 100 ft of Buildings 561 and 587.
- Volatile compounds have been detected in soil within approximately 100 ft of Buildings 561 and 587.

O3.2 RECOMMENDATIONS

Due to source control measures undertaken at the PFSA, volatile compound concentrations have likely attenuated further since the time the soil, groundwater, and vapor samples discussed above were collected. However, in accordance with the approach presented in the main document, VI risk above target levels cannot be ruled out and additional VI evaluation is warranted. A work plan for additional VI assessment should be developed for the PFSA based on the development of the CSM for PFSA and this screening evaluation.

O4.0 REFERENCES

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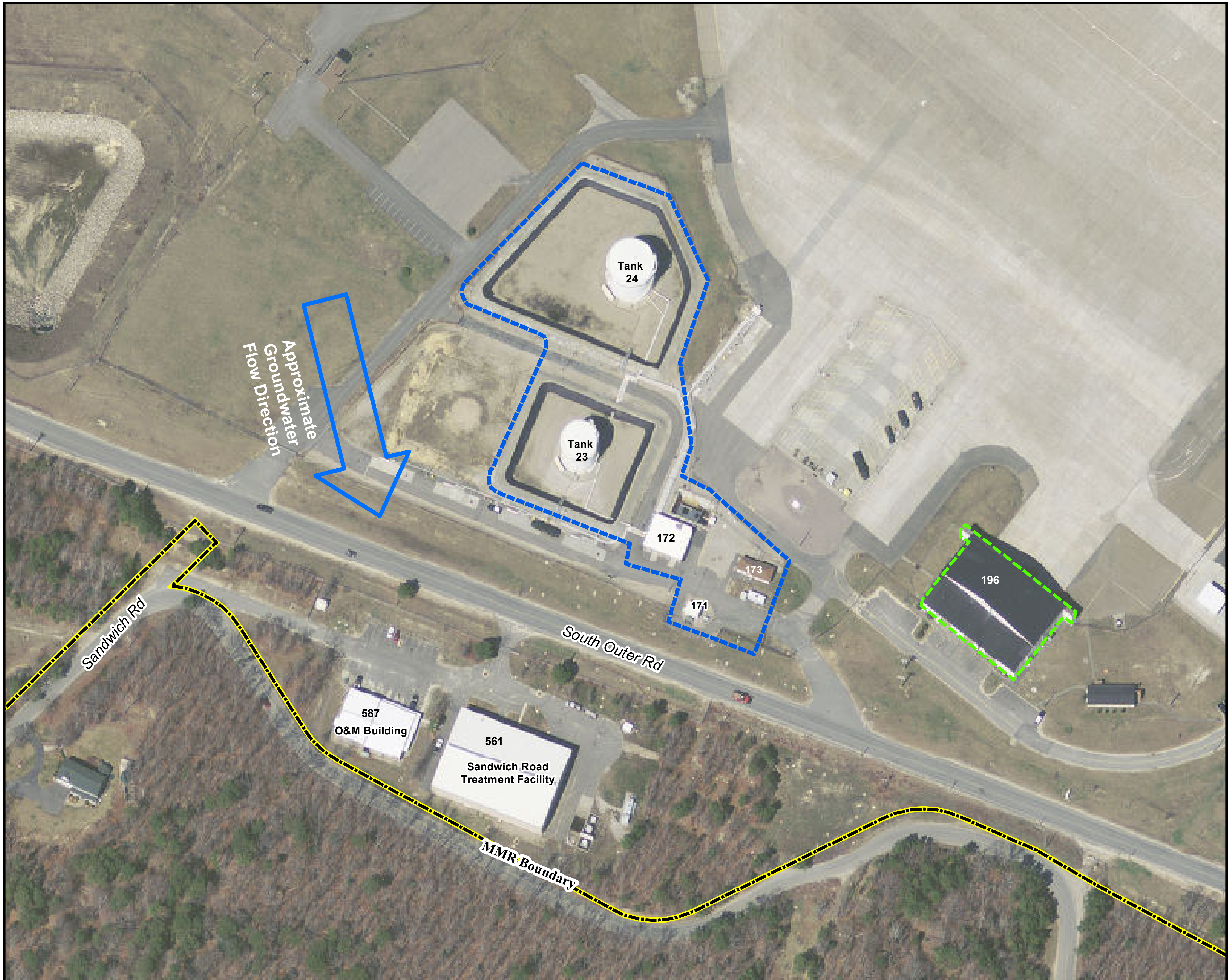

Legend

Massachusetts Military Reservation Boundary

PFSA Structures Demolished January/February 2011

Building 196 Demolished Summer 2011

587 Building Number

N

0 70 140 Feet

Data Source: AFCEE, MMR-AFCEE Data Warehouse
2009 Aerial Photography from MassGIS

FIGURE O-1

PFSA AREA
AFCEE - Massachusetts Military Reservation
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

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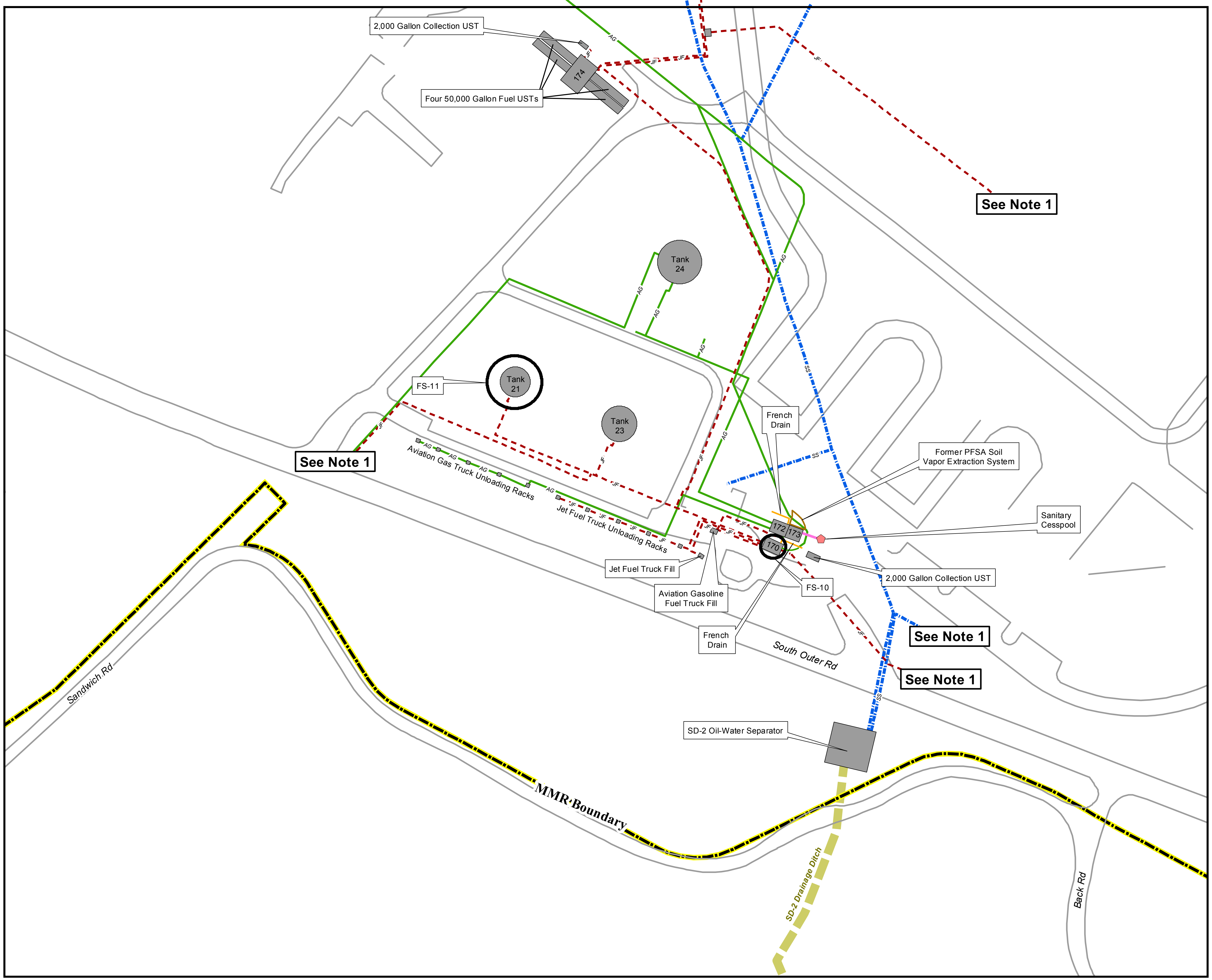

Legend

- Massachusetts Military Reservation Boundary
- Drainage Ditch
- Jet Fuel JP-4 Pipeline (1962)
- Aviation Gas Pipeline (1962)
- Storm Sewer to Oil/Water Separator
- French Drain
- Sanitary Cesspool
- 174 Building/Tank Number

Notes:

1. The extent of utilities outside the area of interest for this Vapor Intrusion Evaluation are not shown. Further information regarding utility locations is available from the MMR 102nd Intelligence Wing/Civil Engineering.

2. Locations shown as features on this figure are approximate and estimated based on the following sources:
   a) Figures 2-2 and 2-3 from the "Final Remedial Investigation Report Petroleum Fuels Storage Area," December 1996, prepared by ABB Environmental Services, Inc.
   b) Figure 2-4 from the "Final Six Areas of Contamination Source Area Feasibility Study," November 1997, prepared by ABB Environmental Services, Inc.
   c) Figure 7-4 from the "Final Record of Decision, Areas of Contamination FTA-2/LF-2, PFSA/FS-10/FS-11, SD-2/FS-6/FS-8, SD-3/FTA-3/CY-4, SD-4, and SD-5/FS-5 Source Areas," September 1998, prepared by Harding Lawson Associates.
   d) Original source map from "Detail Utilities Map - Grid No. 79 - Otis Air Force Base, Massachusetts - Air Reference Command Master Plan," March 1962.
   e) The presence, absence, or condition of these features has not been verified.

N

0 70 140 Feet

Data Source: AFCEE, MMR-AFCEE Data Warehouse

FIGURE O-2

PFSA HISTORICAL SITE FEATURES

AFCEE - Massachusetts Military Reservation

Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

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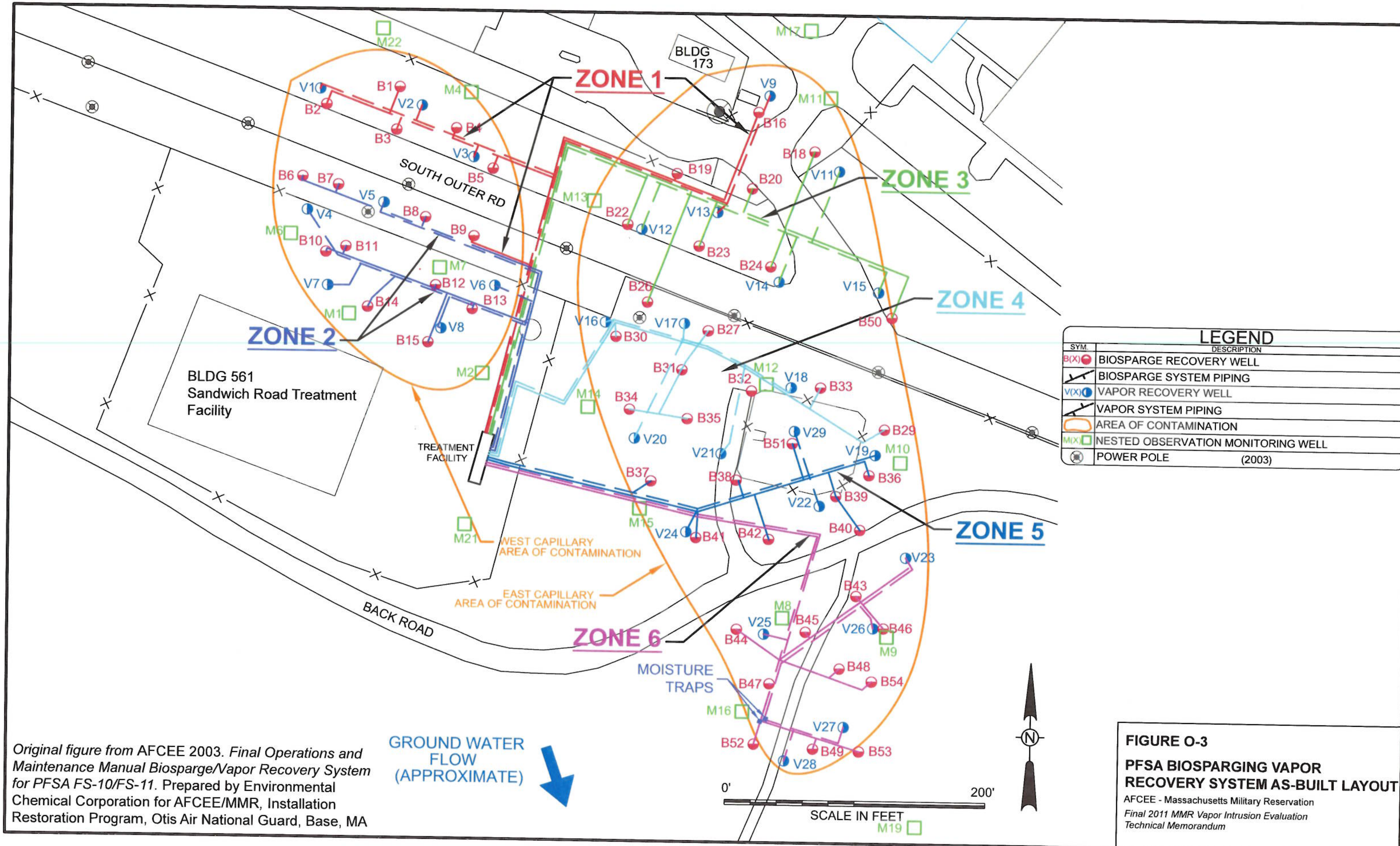

Original figure from AFCEE 2003. *Final Operations and Maintenance Manual Biosparge/Vapor Recovery System for PFSA FS-10/FS-11.* Prepared by Environmental Chemical Corporation for AFCEE/MMR, Installation Restoration Program, Otis Air National Guard, Base, MA

FIGURE O-3

PFSA BIOSPARGING VAPOR RECOVERY SYSTEM AS-BUILT LAYOUT

AFCEE - Massachusetts Military Reservation

Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Legend

- Electrical
- Natural Gas/Chemical
- Communications
- Potable Water
- Treatment System Influent/Effluent
- Sanitary Sewer
- Storm Sewer
- Former Structure
- Extraction/Reinjection Well

Note:
Refer to Table O-2 for definitions of number labels associated with specific utility lines included in this figure.

0 130 Feet

Source: Data source statement here

FIGURE O-4

PFSA EXISTING SUBSURFACE UTILITIES

AFCEE - Massachusetts Military Reservation

Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

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Legend

- Massachusetts Military Reservation Boundary
- 24MW412A (2010) — Locations With an Exceedance of a VI COPC Screening Value*
- 24MW414A (2010) — Location with VI COPC Detection Below its Screening Value*
- 24MW410A (2009) — Location with No VI COPC Detections*
- PFSA Structures Demolished January/ February 2011
- Building 196 Demolished Summer 2011
- 100' Buffer Around Buildings of Interest

Notes:

*Date refers to the most recent date of sample collection

VI COPC: vapor intrusion contaminant of potential concern.

Groundwater samples were collected at or near the water table. Refer to Table 4-1 of main document for a list of VI COPCs and associated groundwater to indoor air screening values.

N

0 70 140 Feet

Data Source: AFCEE, MMR-AFCEE Data Warehouse
2009 Aerial Photography from MassGIS

FIGURE O-5

PFSA GROUNDWATER DATA SUMMARY

AFCEE - Massachusetts Military Reservation

Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

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Legend

- Massachusetts Military Reservation Boundary
- 24BH425 — Locations With Volatile Compound Detection(s)
- 24DP432 — Locations Without Volatile Compound Detection(s)
- PFSA Structures Demolished January/ February 2011
- Building 196 Demolished Summer 2011
- 100' Buffer Around Buildings of Interest

Notes:
Soil samples were collected at or near the water table

0 70 140 Feet

Data Source: AFCEE, MMR-AFCEE Data Warehouse
2009 Aerial Photography from MassGIS

FIGURE O-6

PFSA SOIL DATA SUMMARY
AFCEE - Massachusetts Military Reservation
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

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Table O-1
PFSA Depth Information Summary
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Site Feature or System Component	Depth Range (ft bgs)
Depth to Groundwater	29 to 63*
Capillary Fringe Impacted Soil in Western Portion of PFSA	54-64
Capillary Fringe Impacted Soil in Eastern Portion of PFSA	38-58
Biosparging Well Screens	58-60 to 68-70
Soil Vapor Extraction Well Screens	20-30
PFSA Groundwater Sample Collection Depth (from Table O-4)	37-63
PFSA Soil Sample Collection Depth (from Table O-6)	33-69

Source: AFCEE. 2003. *Final Operations and Maintenance Manual Biosparge/Vapor Recovery System for PFSA FS-10/FS-11*. Prepared by Environmental Chemical Corporation for AFCEE/MMR, Installation Restoration Program, Otis Air National Guard Base, MA.

* This range of groundwater depths equates to groundwater elevations ranging from approximately 38 to 55 feet mean sea level. Note that these groundwater elevation ranges are likely influenced by the current or historic operation of nearby groundwater remedial systems and do not necessarily represent ambient conditions.

Key:
ft bgs = feet below ground surface
BSVR = biosparging/vapor recovery

Table O-2
PFSA Details on Existing Subsurface Utilities
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Subsurface Utility Description	References[1]
Building 561, Constructed in 1997	
Electrical and Communications Conduit	
1. From base grid connection along South Outer Road to Building 561 transformer pad – two 4" PVC conduits, 2'4" depth, 1'6" width; connects to utility pole on South Outer Road.	1,2,4
2. From Building 561 transformer pad to Building 561 – three 4" and one 2" PVC conduits, 2'4" depth, 3' width	1,2,4
3. From base communications grid along South Outer Rd. to Building 561 – one 4" and one 2" PVC conduit, 2'4" depth, 1'6" width; connects to utility pole on South Outer Road.	1,2,4
4. From Building 561 to reinjection well vaults - two 4", two 2", one 3" PVC conduits, 3' 3.5" depth, 1'6" width.	1,2,3
5. From Building 561 to motor control center - one 4" and one 2" PVC conduit, 2'4" depth, 2' width.	1,2,3
Groundwater Extraction Pipelines	
6. From Sandwich Road and SD-5N extraction well vaults to south side of Building 561 –12" HDPE double-wall pipe, 3' depth, 3' width*.	1,5
7. From SD-5S extraction well vaults to east side of Building 561 –12" HDPE double-wall pipe, 3' depth, 3' width*.	1,6
Groundwater Reinjection Pipelines	
8. From south side of Building 561 to Sandwich Road reinjection well vaults –8" HDPE pipe, 3' depth, 3' width*.	1,7
Chemical Piping from Storage Tanks	
9. Three 4" HDPE secondary containment pipes. 3' depth* and 3' width*. Stub-ups outside the building. No slab penetration.	1
Natural Gas	
10. From base main along South Outer Road to Building 587 – 1 pipe, 1'6" depth* and 2' width*. Stub-up outside the building. No slab penetration.	8
Potable Water	
11. From base main along South Outer Road to Building 587 – 3/4" pipe, 3' depth* and 2' width*.	8
Septic	
12. From Building 561 to septic system - 3' depth* and 2' width*.	1
Building 587, Constructed in 2003	
Electrical and Communications Conduit	
13. From Building 561 transformer pad to Building 587 transformer pad - two 4" ducts in 1'4" ft wide, 10" thick concrete duct bank.	8
14. From Building 587 transformer pad to Building 587 – 1'6" depth* and 2' width*.	8
15. From Building 587 to sanitary sewer pump station – 1'6" depth* and 2' width*.	8
16. From Building 561 to Building 587 – two 4" conduits, 1'6" depth* and 3' width*.	8
17. From base communications grid along South Outer Road to Building 587 – 1'6" depth* and 2' width*; connects to utility pole on South Outer Road.	8
Sanitary Sewer	
18. From Building 587 to sanitary sewer pump station - one 4" PVC pipe, 5' depth, 2' width*.	8
Natural Gas	
19. From base main along South Outer Road to Building 587 – 1" pipe, 1'6" depth, 2' width*. Stub-up outside the building. No slab penetration.	8
Potable Water	
20. From base main along South Outer Road to Building 587 – 3/4" HDPE pipe, 4' depth, 2' width*.	8

Table O-2
PFSA Details on Existing Subsurface Utilities
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Subsurface Utility Description	References[1]
Base Utilities Along South Outer Road	
Communications Conduit	
21. Along north side of South Outer Road – 1'6" depth* and 2' width*.	9
Sanitary Sewer	
22. Along north side of South Outer Road – 5' depth*, 2' width*.	9
23. Along south side of South Outer Road – 5' depth*, 2' width*.	9
Natural Gas	
24. Along north side of South Outer Road – 8" plastic pipe, 2' depth*, 3' width*.	9
Potable Water	
25. Along north side of South Outer Road – 10" pipe, 3' depth*, 3' width*.	9

Key:

AFCEE = Air Force Center for Engineering and the Environment

CS-10 = Chemical Spill-10

HDPE = high density polyethylene

MMR = Massachusetts Military Reservation

PFSA = Petroleum Fuel Storage Area

PVC = polyvinyl chloride

SD-5 = Storm Drain-5

Notes:

Although details on joining methods are not available, lengths of PVC electrical conduit and PVC piping are typically joined by solvent-welded slip-fit connections.

Lengths of HDPE water piping for extracted and treated groundwater are joined by heat fusion-welding.

Results of any sewer line leak tests are not available, although they may exist in AFCEE archives.

Buildings 561 and 587 were purpose-built to treat contaminated groundwater associated with the SD-5 and CS-10 chlorinated volatile organic compound plumes (Building 561) and to house operations and maintenance staff and facilities associated with AFCEE's MMR remediation project (Building 587). Future plans (if any) for the use of these facilities after the remediation project has been completed are unknown.

* Indicated trench dimensions are estimates based on typical local construction practices and size of the buried utility.

[1]: The following list of references corresponds to the source for the information provided in this table.

1. AFCEE MMR Plume Response Project, Otis ANGB, MA, CS-10 Sandwich Road Fence; Civil Wellfield and Pipeline Plan, Jacobs Drawing Number 35Q85205-3-03-C-N-A-003, Rev. 1.
2. AFCEE MMR Plume Response Project, Storm Drain-5 Plume; Treatment Unit Underground Electrical Plan, Jacobs Drawing Number SD05-1115-356, Rev. 1.
3. AFCEE MMR Plume Response Project, Storm Drain-5 Plume; Underground Conduit Electrical Sections, Jacobs Drawing Number SD05-1115-120, Rev. 1.
4. AFCEE MMR Plume Response Project, Storm Drain-5 Plume; Underground Sections & Details, Jacobs Drawing Number SD05-1115-121, Rev. 1.
5. AFCEE MMR Plume Response Project, Otis ANGB, MA, CS-10 Sandwich Road Fence; Civil Piping and Instrument Diagram, Extraction Well Header, Jacobs Drawing Number 35Q85205-3-03-C-I-0001, Rev. 1.
6. AFCEE MMR Plume Response Project, Otis ANGB, MA, DO-13 Mod 1; Civil Site Layout Plan, TCE SD-5 South, Jacobs Drawing Number 35S18805-3-95-C-P-A-009, Rev. 3.
7. AFCEE MMR Plume Response Project, Otis ANGB, MA, CS-10 Sandwich Road Fence; Civil Piping and Instrument Diagram, Reinjection Well Header, Jacobs Drawing Number 35Q85205-3-03-C-I-0002, Rev. 1.
8. AFCEE MMR Plume Response Project, Otis ANGB, MA, TO-31; Civil O&M Facility Site Utility Plan, Jacobs Drawing Number 35Z03102-3-36-C-V-A-003, Rev. 0.
9. Dept. of the Air Force, Air Defense Command Master Plan, Detail Utilities Map - Grid No. 79, Otis Air Force Base, Massachusetts, Tab No. G-7, Sheet 35 of 86, Rev. 3.

Table O-3
PFSA Soil Boring and Monitoring Well Construction Information
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Location	Northing (ft)	Easting (ft)	Surface Elevation (ft msl)	Measuring Point Elevation (ft msl)	Total Well Depth (ft bgs)	Top Screen Depth (ft bgs)	Bottom Screen Depth (ft bgs)	Top Screen Elevation (ft msl)	Bottom Screen Elevation (ft msl)	Screen Length (ft)
Groundwater Locations										
24MW0304A	236309	865403	104	106.70	62	52.00	62.00	52.30	42.30	10
24MW401A	236108	865388	105	103.65	62	52.00	62.00	52.52	42.52	10
24MW402A	236074	865494	103	101.78	62	52.00	62.00	50.52	40.52	10
24MW403A	236166	865519	101	100.78	62	52.00	62.00	49.47	39.47	10
24MW404A	236289	865481	103	102.37	64	54.00	64.00	49.34	39.34	10
24MW406A	236179	865346	104	102.99	62	52.00	62.00	51.91	41.91	10
24MW407A	236152	865460	104	102.80	62	52.00	62.00	51.63	41.63	10
24MW408A	235895	865724	85	83.90	42	32.00	42.00	52.65	42.65	10
24MW409A	235877	865807	93	92.35	52	42.00	52.00	51.09	41.09	10
24MW410A	236011	865812	90	89.09	52	42.00	52.00	47.92	37.92	10
24MW411A	236319	865800	104	103.44	64	54.00	64.00	50.14	40.14	10
24MW412A	236065	865710	89	87.75	52	42.00	52.00	46.73	36.73	10
24MW413A	236221	865601	102	101.48	64	54.00	64.00	48.39	38.39	10
24MW414A	236048	865577	99	98.55	62	52.00	62.00	47.35	37.35	10
24MW415A	235968	865615	94	93.43	54	44.00	54.00	50.13	40.13	10
24MW416A	235825	865694	82	80.85	42	32.00	42.00	49.64	39.64	10
24MW417A	236169	865696	102	100.93	64	54.00	64.00	47.79	37.79	10
24MW418A	235723	865722	86	85.07	45	35.00	45.00	50.83	40.83	10
24MW421A	235953	865480	102	100.95	62	52.00	62.00	49.78	39.78	10
24MW422A	236328	865386	105	103.72	60	50.00	60.00	54.58	44.58	10
28BH0576*	236025	865683	87	NA[1]	NA[1]	NA[1]	NA[1]	NA[1]	NA[1]	NA[1]
28BH0581	236322	864910	104	NA[1]	NA[1]	NA[1]	NA[1]	NA[1]	NA[1]	NA[1]
28BH0582*	236240	864679	104	NA[1]	NA[1]	NA[1]	NA[1]	NA[1]	NA[1]	NA[1]
28MW0019A	236346	864874	104	107.06	79	74.00	79.00	29.90	24.90	5
28MW0574	236786	864960	106	108.04	82	77.00	82.00	29.25	24.25	5
28MW0588*	236216	865146	103	103.39	60	49.70	54.70	53.70	48.70	5
28MW0589*	236258	865109	103	103.02	60	50.00	55.00	53.20	48.20	5
28MW0590	236171	865141	103	102.97	60	49.80	54.80	53.30	48.30	5
28MW0591A*	236162	865316	104	103.62	85	80.00	85.00	23.90	18.90	5
28MW0592C	236311	864859	104	103.18	64	59.00	64.00	44.65	39.65	5
28MW0593C	236238	865051	103	103.10	64	59.00	64.00	44.37	39.37	5
28MW0594C	236155	865048	104	105.17	58	53.10	58.30	50.51	45.31	5
28MW0595C	236144	864663	104	106.39	64	59.00	64.00	44.98	39.98	5
28PZ0583*	236242	865142	103	103.19	118	88.20	118.20	15.20	-14.80	30
28PZ0584*	236254	865062	103	103.15	118	88.20	118.20	15.20	-14.80	30
28PZ0585	236171	865147	103	103.04	118	88.20	118.20	15.00	-15.00	30
91MW0313B	236100	865537	102	104.49	59	49.00	59.00	52.50	42.50	10
Soil Locations										
24BH0501	236287	865604	101	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24BH0502	236296	865646	101	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24BH0503	236310	865632	101	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24BH0504	236273	865665	101	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24BH0505	236230	865615	101	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24BH0506	236213	865622	101	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24BH0507	236254	865607	101	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24BH0508	236242	865585	101	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24BH0509	236234	865657	101	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24BH0510	236256	865652	101	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24BH0511	236240	865631	101	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24BH0512	236254	865694	101	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]

Table O-3
PFSA Soil Boring and Monitoring Well Construction Information
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Location	Northing (ft)	Easting (ft)	Surface Elevation (ft msl)	Measuring Point Elevation (ft msl)	Total Well Depth (ft bgs)	Top Screen Depth (ft bgs)	Bottom Screen Depth (ft bgs)	Top Screen Elevation (ft msl)	Bottom Screen Elevation (ft msl)	Screen Length (ft)
24BH0513	236233	865697	101	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24BH0514	236254	865714	101	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24BH0515	236212	865592	101	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24BH0516	236164	865670	101	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24BH0517	236184	865685	101	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24BH0518	236177	865702	101	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24BH0519	236208	865708	101	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24BH0520	236138	865640	102	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24BH0521	236152	865767	101	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24BH0522	236118	865784	102	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24BH0523	236162	865821	100	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24BH407	236292	865416	100	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24BH408	236134	865454	102	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24BH409	236377	865513	96	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24BH410	236317	865283	102	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24BH411	236302	865317	99	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24BH412	236114	865457	101	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24BH413	236332	865492	95	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24BH414	236333	865241	102	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24BH415	236185	865314	101	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24BH416	236176	865698	96	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24BH417	236138	865802	95	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24BH418	236042	865695	91	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24BH419	236216	865624	98	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24BH420	236159	865765	102	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24BH421	236003	865682	89	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24BH422	236233	865554	99	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24BH423	236276	865696	100	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24BH424	236342	865731	101	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24BH425	235934	865696	85	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24BH7300	236747	864979	105	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24BH7301	236711	865073	105	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24BH7302	236666	865053	105	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24BH7303	236703	864961	105	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24BH7304	236657	864942	102	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24BH7305	236618	865035	103	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24BH7306	236572	865016	102	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24BH7307	236609	864924	105	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24BH7308	236563	864905	105	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24BH7320	236584	865224	102	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24BH7321	236537	865205	102	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24BH7322	236491	865186	102	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24BH7323	236519	865252	88	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24BH7324	236566	865270	99	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24BH7325	236547	865316	101	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24BH7327	236453	865279	99	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24BH7328	236528	865281	88	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24BHA1-06	236326	865365	104	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24BHB1	236287	865357	115	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24BHB2	236300	865413	116	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24BHB2-06	236296	865404	103	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24BHB3	236284	865458	115	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24BHB4	236299	865511	117	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24BHB7	236295	865646	117	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24BHB9	236282	865763	120	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24BHC1	236228	865362	117	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24BHC2-06	236225	865403	102	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24BHC3	236250	865456	114	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]

Table O-3
PFSA Soil Boring and Monitoring Well Construction Information
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Location	Northing (ft)	Easting (ft)	Surface Elevation (ft msl)	Measuring Point Elevation (ft msl)	Total Well Depth (ft bgs)	Top Screen Depth (ft bgs)	Bottom Screen Depth (ft bgs)	Top Screen Elevation (ft msl)	Bottom Screen Elevation (ft msl)	Screen Length (ft)
24BHC4	236233	865501	117	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24BHC4-06	236266	865534	105	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24BHC6	236234	865616	114	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24BHC7	236232	865654	118	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24BHC7300	236563	864904	105	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24BHC7301	236571	865014	102	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24BHC8	236231	865698	119	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24BHC9	236231	865746	115	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24BHD2	236188	865414	117	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24BHD3	236193	865439	115	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24BHD3-06	236177	865438	102	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24BHD4	236189	865505	117	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24BHD6	236189	865607	116	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24BHD7	236189	865655	115	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24BHD8	236178	865703	115	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24BHD9	236195	865760	116	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24BHE1	236131	865359	119	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24BHE2	236141	865405	121	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24BHE3-06	236143	865452	102	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24BHE4	236127	865509	121	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24BHE4-06	236155	865504	102	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24BHE5-06	236143	865553	100	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24BHE6	236150	865596	116	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24BHE9	236136	865754	116	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24BHF2-06	236075	865418	102	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24BHF3	236089	865456	120	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24BHF3-06	236107	865452	102	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24BHF4-06	236088	865502	102	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24BHG4-06	236056	865486	102	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24BHS1	236112	865473	98	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24BHS2	236172	865373	98	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24BHS3	235929	865473	97	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24DP400	236487	865251	100	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24DP401	236470	865242	100	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24DP402	236377	865395	97	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24DP404	236348	865608	101	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24DP405	236355	865627	102	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24DP406	236399	865612	106	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24DP426	235961	865331	108	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24DP427	235982	865471	98	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24DP428	235990	865284	96	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24DP429	236099	865390	110	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24DP430	236516	865274	101	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24DP431	236334	865375	103	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24DP432	236073	865593	100	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24DP433	235900	865642	89	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24DP434	235786	865528	110	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24DP435	235837	865686	90	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24DP436	235833	865737	88	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24DP437	235910	865831	97	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24DP438	235683	865697	85	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24IW412	236141	865458	98	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24PE1	236306	865389	115	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24PE10	236070	865665	95	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24PE11	236048	865798	98	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24PE12	235994	865639	90	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24PE13	236011	865718	93	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24PE14	235982	865803	96	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]

Table O-3
PFSA Soil Boring and Monitoring Well Construction Information
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Location	Northing (ft)	Easting (ft)	Surface Elevation (ft msl)	Measuring Point Elevation (ft msl)	Total Well Depth (ft bgs)	Top Screen Depth (ft bgs)	Bottom Screen Depth (ft bgs)	Top Screen Elevation (ft msl)	Bottom Screen Elevation (ft msl)	Screen Length (ft)
24PE15	235891	865685	88	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24PE16	235897	865815	97	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24PE17	235787	865739	90	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24PE2	236274	865485	115	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24PE3	236211	865364	116	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24PE4	236175	865460	115	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24PE5	236306	865722	118	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24PE6	236218	865594	115	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24PE7	236189	865687	115	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24PE8	236187	865783	116	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
24PE9	236081	865589	100	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
MW18	235726	865721	95	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]

Data Source: AFCEE, May 2011, MMR-AFCEE Data Warehouse

Key:
bgs = below ground surface
ft = feet
msl = mean sea level
NA[1] = Not Applicable - locations are direct push vertical profile borings and have no permanent screens.
NA[2] = Not Applicable - locations are soil borings and have no well screens installed.
* = This table contains well construction information for permanent monitoring wells. However, additional groundwater profile data was collected at these locations. Refer to Table O-4.

Table O-4
Comparison of Detected Concentrations in PFSA Groundwater
to Applicable Groundwater-to-Indoor Air Screening Values
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Location Identification	Sample Date	Sample Depth (ft bgs)	Sampling Method[1]	VI COPC	Result (µg/L)	DL (µg/L)	RL (µg/L)	MCP Method 1 GW-2 Standard[2] (µg/L)	VI Screening Value Exceeded?	Generic Unrestricted Groundwater Screening Value[3] (µg/L)	VI Screening Value Exceeded?
24MW0304A	10/1/1999	57	MW	ETHYLBENZENE	18	0.38	4	20,000	No	700	No
24MW0304A	10/1/1999	57	MW	XYLENES, TOTAL	140	1.2	4	9,000	No	10,000	No
24MW401A	2/9/2010	57	MW	1,2,4-TRIMETHYLBENZENE	**14**	0.27	1	NE	NA	7.8	Yes
24MW401A	2/9/2010	57	MW	1,3,5-TRIMETHYLBENZENE (MESITYLENE)	4.1	0.21	1	NE	NA	7.8	No
24MW401A	2/9/2010	57	MW	C5-C8 ALIPHATIC HYDROCARBONS	BRL	0.76	50	3,000	No	NE	NA
24MW401A	2/9/2010	57	MW	C9-C10 AROMATIC HYDROCARBONS	93.3	1.2	50	7,000	No	NE	NA
24MW401A	2/9/2010	57	MW	C9-C12 ALIPHATIC HYDROCARBONS	59.9	1.54	50	5,000	No	NE	NA
24MW402A	2/5/2010	57	MW	1,2,4-TRIMETHYLBENZENE	**11**	0.27	1	NE	NA	7.8	Yes
24MW402A	2/5/2010	57	MW	C9-C10 AROMATIC HYDROCARBONS	61.2	1.2	50	7,000	No	NE	NA
24MW402A	2/5/2010	57	MW	ETHYLBENZENE	BRL	0.26	1	20,000	No	700	No
24MW403A	2/9/2010	57	MW	1,2,4-TRIMETHYLBENZENE	**62**	0.27	1	NE	NA	7.8	Yes
24MW403A	2/9/2010	57	MW	1,3,5-TRIMETHYLBENZENE (MESITYLENE)	**17**	0.21	1	NE	NA	7.8	Yes
24MW403A	2/9/2010	57	MW	C5-C8 ALIPHATIC HYDROCARBONS	93.2J	1.52	100	3,000	No	NE	NA
24MW403A	2/9/2010	57	MW	C9-C10 AROMATIC HYDROCARBONS	335	2.4	100	7,000	No	NE	NA
24MW403A	2/9/2010	57	MW	C9-C12 ALIPHATIC HYDROCARBONS	209	3.08	100	5,000	No	NE	NA
24MW403A	2/9/2010	57	MW	ETHYLBENZENE	BRL	0.26	1	20,000	No	700	No
24MW404A	2/8/2010	59	MW	1,2,4-TRIMETHYLBENZENE	**57**	0.27	1	NE	NA	7.8	Yes
24MW404A	2/8/2010	59	MW	1,3,5-TRIMETHYLBENZENE (MESITYLENE)	**17**	0.21	1	NE	NA	7.8	Yes
24MW404A	2/8/2010	59	MW	C11-C22 AROMATIC HYDROCARBONS	BRL	37	100	50,000	No	NE	NA
24MW404A	2/8/2010	59	MW	C5-C8 ALIPHATIC HYDROCARBONS	56.2	0.76	50	3,000	No	NE	NA
24MW404A	2/8/2010	59	MW	C9-C10 AROMATIC HYDROCARBONS	317	1.2	50	7,000	No	NE	NA
24MW404A	2/8/2010	59	MW	C9-C12 ALIPHATIC HYDROCARBONS	174	1.54	50	5,000	No	NE	NA
24MW404A	2/8/2010	59	MW	ETHYLBENZENE	1.6	0.26	1	20,000	No	700	No
24MW406A	2/16/2010	57	MW	1,2,4-TRIMETHYLBENZENE	BRL	0.27	1	NE	NA	7.8	No
24MW406A	2/16/2010	57	MW	C9-C10 AROMATIC HYDROCARBONS	BRL	1.2	50	7,000	No	NE	NA
24MW406A	2/16/2010	57	MW	C9-C12 ALIPHATIC HYDROCARBONS	BRL	1.54	50	5,000	No	NE	NA
24MW408A	2/12/2010	37	MW	1,2,4-TRIMETHYLBENZENE	**67**	0.27	1	NE	NA	7.8	Yes
24MW408A	2/12/2010	37	MW	1,3,5-TRIMETHYLBENZENE (MESITYLENE)	**27**	0.21	1	NE	NA	7.8	Yes
24MW408A	2/12/2010	37	MW	C11-C22 AROMATIC HYDROCARBONS	113	37	100	50,000	No	NE	NA
24MW408A	2/12/2010	37	MW	C5-C8 ALIPHATIC HYDROCARBONS	424	0.76	50	3,000	No	NE	NA
24MW408A	2/12/2010	37	MW	C9-C10 AROMATIC HYDROCARBONS	455	1.2	50	7,000	No	NE	NA
24MW408A	2/12/2010	37	MW	C9-C12 ALIPHATIC HYDROCARBONS	77.6	1.54	50	5,000	No	NE	NA
24MW408A	2/12/2010	37	MW	C9-C18 ALIPHATIC HYDROCARBONS	BRL	6.14	100	5,000	No	NE	NA
24MW408A	2/12/2010	37	MW	ETHYLBENZENE	3.5	0.26	1	20,000	No	700	No
24MW409A	2/12/2010	47	MW	1,2,4-TRIMETHYLBENZENE	**13**	0.27	1	NE	NA	7.8	Yes
24MW409A	2/12/2010	47	MW	1,3,5-TRIMETHYLBENZENE (MESITYLENE)	1.3	0.21	1	NE	NA	7.8	No
24MW409A	2/12/2010	47	MW	C11-C22 AROMATIC HYDROCARBONS	BRL	37	100	50,000	No	NE	NA
24MW409A	2/12/2010	47	MW	C5-C8 ALIPHATIC HYDROCARBONS	69.5	0.76	50	3,000	No	NE	NA
24MW409A	2/12/2010	47	MW	C9-C10 AROMATIC HYDROCARBONS	185	1.2	50	7,000	No	NE	NA
24MW409A	2/12/2010	47	MW	C9-C12 ALIPHATIC HYDROCARBONS	BRL	1.54	50	5,000	No	NE	NA
24MW409A	2/12/2010	47	MW	C9-C18 ALIPHATIC HYDROCARBONS	BRL	6.14	100	5,000	No	NE	NA
24MW409A	2/12/2010	47	MW	ETHYLBENZENE	BRL	0.26	1	20,000	No	700	No
24MW412A	2/11/2010	47	MW	1,2,4-TRIMETHYLBENZENE	**150**	2.7	10	NE	NA	7.8	Yes

Table O-4
Comparison of Detected Concentrations in PFSA Groundwater
to Applicable Groundwater-to-Indoor Air Screening Values
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Location Identification	Sample Date	Sample Depth (ft bgs)	Sampling Method[1]	VI COPC	Result (µg/L)	DL (µg/L)	RL (µg/L)	MCP Method 1 GW-2 Standard[2] (µg/L)	VI Screening Value Exceeded?	Generic Unrestricted Groundwater Screening Value[3] (µg/L)	VI Screening Value Exceeded?
24MW412A	2/11/2010	47	MW	1,3,5-TRIMETHYLBENZENE (MESITYLENE)	**61**	2.1	10	NE	NA	7.8	Yes
24MW412A	2/11/2010	47	MW	C11-C22 AROMATIC HYDROCARBONS	BRL	38.1	103	50,000	No	NE	NA
24MW412A	2/11/2010	47	MW	C5-C8 ALIPHATIC HYDROCARBONS	400	0.76	50	3,000	No	NE	NA
24MW412A	2/11/2010	47	MW	C9-C10 AROMATIC HYDROCARBONS	574	1.2	50	7,000	No	NE	NA
24MW412A	2/11/2010	47	MW	C9-C12 ALIPHATIC HYDROCARBONS	85.1	1.54	50	5,000	No	NE	NA
24MW412A	2/11/2010	47	MW	ETHYLBENZENE	88	2.6	10	20,000	No	700	No
24MW413A	2/8/2010	59	MW	1,2,4-TRIMETHYLBENZENE	**38**	0.27	1	NE	NA	7.8	Yes
24MW413A	2/8/2010	59	MW	1,3,5-TRIMETHYLBENZENE (MESITYLENE)	**19**	0.21	1	NE	NA	7.8	Yes
24MW413A	2/8/2010	59	MW	C11-C22 AROMATIC HYDROCARBONS	BRL	37	100	50,000	No	NE	NA
24MW413A	2/8/2010	59	MW	C5-C8 ALIPHATIC HYDROCARBONS	74.2	0.76	50	3,000	No	NE	NA
24MW413A	2/8/2010	59	MW	C9-C10 AROMATIC HYDROCARBONS	156	1.2	50	7,000	No	NE	NA
24MW413A	2/8/2010	59	MW	C9-C12 ALIPHATIC HYDROCARBONS	87.1	1.54	50	5,000	No	NE	NA
24MW414A	2/16/2010	57	MW	C11-C22 AROMATIC HYDROCARBONS	116	37.8	102	50,000	No	NE	NA
24MW414A	2/16/2010	57	MW	C5-C8 ALIPHATIC HYDROCARBONS	268	0.76	50	3,000	No	NE	NA
24MW414A	2/16/2010	57	MW	C9-C10 AROMATIC HYDROCARBONS	BRL	1.2	50	7,000	No	NE	NA
24MW414A	2/16/2010	57	MW	C9-C12 ALIPHATIC HYDROCARBONS	52.7	1.54	50	5,000	No	NE	NA
24MW415A	2/16/2010	49	MW	C5-C8 ALIPHATIC HYDROCARBONS	BRL	0.76	50	3,000	No	NE	NA
24MW415A	2/16/2010	49	MW	C9-C10 AROMATIC HYDROCARBONS	BRL	1.2	50	7,000	No	NE	NA
24MW415A	2/16/2010	49	MW	C9-C12 ALIPHATIC HYDROCARBONS	BRL	1.54	50	5,000	No	NE	NA
24MW416A	2/12/2010	37	MW	1,2,4-TRIMETHYLBENZENE	**8.9**	0.27	1	NE	NA	7.8	Yes
24MW416A	2/12/2010	37	MW	1,3,5-TRIMETHYLBENZENE (MESITYLENE)	4.2	0.21	1	NE	NA	7.8	No
24MW416A	2/12/2010	37	MW	C11-C22 AROMATIC HYDROCARBONS	BRL	37	100	50,000	No	NE	NA
24MW416A	2/12/2010	37	MW	C5-C8 ALIPHATIC HYDROCARBONS	149	0.76	50	3,000	No	NE	NA
24MW416A	2/12/2010	37	MW	C9-C10 AROMATIC HYDROCARBONS	98.9	1.2	50	7,000	No	NE	NA
24MW416A	2/12/2010	37	MW	C9-C12 ALIPHATIC HYDROCARBONS	BRL	1.54	50	5,000	No	NE	NA
24MW416A	2/12/2010	37	MW	C9-C18 ALIPHATIC HYDROCARBONS	BRL	6.14	100	5,000	No	NE	NA
24MW416A	2/12/2010	37	MW	ETHYLBENZENE	1.1	0.26	1	20,000	No	700	No
24MW417A	2/8/2010	59	MW	1,3,5-TRIMETHYLBENZENE (MESITYLENE)	**66**	0.84	4	NE	NA	7.8	Yes
24MW417A	2/8/2010	59	MW	C11-C22 AROMATIC HYDROCARBONS	BRL	37	100	50,000	No	NE	NA
24MW417A	2/8/2010	59	MW	C5-C8 ALIPHATIC HYDROCARBONS	498	3.8	250	3,000	No	NE	NA
24MW417A	2/8/2010	59	MW	C9-C10 AROMATIC HYDROCARBONS	584	6	250	7,000	No	NE	NA
24MW417A	2/8/2010	59	MW	C9-C12 ALIPHATIC HYDROCARBONS	349	7.7	250	5,000	No	NE	NA
24MW417A	2/8/2010	59	MW	ETHYLBENZENE	15	1.1	4	20,000	No	700	No
24MW418A	2/12/2010	40	MW	C11-C22 AROMATIC HYDROCARBONS	BRL	37	100	50,000	No	NE	NA
24MW418A	2/12/2010	40	MW	C5-C8 ALIPHATIC HYDROCARBONS	86.6	0.76	50	3,000	No	NE	NA
24MW418A	2/12/2010	40	MW	C9-C10 AROMATIC HYDROCARBONS	65.7	1.2	50	7,000	No	NE	NA
24MW418A	2/12/2010	40	MW	C9-C12 ALIPHATIC HYDROCARBONS	BRL	1.54	50	5,000	No	NE	NA
24MW421A	2/5/2010	57	MW	C9-C10 AROMATIC HYDROCARBONS	BRL	1.2	50	7,000	No	NE	NA
24MW422A	2/9/2010	55	MW	1,2,4-TRIMETHYLBENZENE	**16**	0.27	1	NE	NA	7.8	Yes
24MW422A	2/9/2010	55	MW	1,3,5-TRIMETHYLBENZENE (MESITYLENE)	5.3	0.21	1	NE	NA	7.8	No
24MW422A	2/9/2010	55	MW	C5-C8 ALIPHATIC HYDROCARBONS	55	0.76	50	3,000	No	NE	NA
24MW422A	2/9/2010	55	MW	C9-C10 AROMATIC HYDROCARBONS	186	1.2	50	7,000	No	NE	NA
24MW422A	2/9/2010	55	MW	C9-C12 ALIPHATIC HYDROCARBONS	117	1.54	50	5,000	No	NE	NA

Table O-4
Comparison of Detected Concentrations in PFSA Groundwater
to Applicable Groundwater-to-Indoor Air Screening Values
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Location Identification	Sample Date	Sample Depth (ft bgs)	Sampling Method[1]	VI COPC	Result (µg/L)	DL (µg/L)	RL (µg/L)	MCP Method 1 GW-2 Standard[2] (µg/L)	VI Screening Value Exceeded?	Generic Unrestricted Groundwater Screening Value[3] (µg/L)	VI Screening Value Exceeded?
28BH0576	10/30/1996	57.5	VP	1,2,4-TRIMETHYLBENZENE	3.7	0.13	0.5	NE	NA	7.8	No
28BH0576	10/30/1996	57.5	VP	1,3,5-TRIMETHYLBENZENE (MESITYLENE)	1.7	0.14	0.5	NE	NA	7.8	No
28BH0576	10/30/1996	57.5	VP	ETHYLBENZENE	2.8	0.09	0.5	20,000	No	700	No
28BH0576	10/30/1996	57.5	VP	TRICHLOROETHENE (TCE)	BRL	0.07	0.5	30	No	5	No
28BH0582	11/4/1996	57.5	VP	METHYLENE CHLORIDE	BRL	0.13	0.5	10,000	No	840	No
28MW0588	12/9/1996	52.2	VP	TOLUENE	1	0.13	0.5	50,000	No	4,100	No
28MW0589	12/5/1996	52.5	VP	TOLUENE	2	0.13	0.5	50,000	No	4,100	No
28MW0591A	12/16/1996	62.5	VP	1,2,4-TRIMETHYLBENZENE	**17**	0.13	0.5	NE	NA	7.8	Yes
28MW0591A	12/16/1996	62.5	VP	ETHYLBENZENE	9.6	0.09	0.5	20,000	No	700	No
28MW0591A	12/16/1996	62.5	VP	TOLUENE	BRL	0.07	0.5	50,000	No	4,100	No
28MW0592C	2/10/2003	61.5	MW	TETRACHLOROETHENE (PCE)	BRL	0.146	1	50	No	13	No
28PZ0583	11/6/1996	57.5	VP	TOLUENE	BRL	0.07	0.5	50,000	No	4,100	No
28PZ0584	11/11/1996	57.5	VP	METHYLENE CHLORIDE	BRL	1.08	2	10,000	No	840	No
91MW0313B	2/11/2003	54	MW	ETHYLBENZENE	5.15	0.178	1	20,000	No	700	No

Data Source: AFCEE, June 2012, MMR-AFCEE Data Warehouse

Notes:

Screening values shown (both the MassDEP MCP Method 1 Groundwater-2 screening values and generic unrestricted groundwater screening values) are summarized in Table 4-1 of the main document.

1. Sample collection methodology:
   VP = vertical profile groundwater sampling (direct push, rotosonic, or screened hollow-stem auger methods)
   MW = fixed monitoring well
2. 310 CMR 40.0974(2) http://www.mass.gov/dep/cleanup/laws/0974_2.htm .
3. EPA, 2002, Draft Guidance for Evaluating the VI to Indoor Air Pathway from Groundwater and Soils http://www.epa.gov/osw/hazard/correctiveaction/eis/vapor/complete.pdf, using target risk levels of $1x10^{-6}$ excess lifetime cancer risk and noncancer hazard quotient of 0.1 in accordance with best practices for vapor intrusion screening to account for cumulative effects from multiple chemicals. Values updated using May 2012 Regional Screening Levels (Residential Indoor Air) for Chemical Contaminants at Superfund Sites http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm.

Results in bold exceed a VI screening value.

Key:

BRL = below reporting limit
DL = detection limit
ft bgs = feet below ground surface
J = estimated concentration
MCP = Massachusetts Contingency Plan
MW = monitoring well
NA = not applicable
VP = vertical profiling
NE = not established
RL = reporting limit
µg/L = micrograms per liter
VI COPC = vapor intrusion contaminant of potential concern

Table O-5
PFSA Soil Data Summary
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Location	Year Sampled	VOC Compound Detected?
24BH0508	2007	No
24BH0523	2007	No
24BH417	2000	No
24BH7320	2001	No
24BHE5-06	2006	No
24DP401	2000	No
24DP405	2000	No
24DP406	2000	No
24DP431	2000	No
24DP432	2000	No
24DP434	2000	No
24DP437	2000	No
24DP438	2000	No
24BH0501	2007	Yes
24BH0502	2007	Yes
24BH0503	2007	Yes
24BH0504	2007	Yes
24BH0505	2007	Yes
24BH0506	2007	Yes
24BH0507	2007	Yes
24BH0509	2007	Yes
24BH0510	2007	Yes
24BH0511	2007	Yes
24BH0512	2007	Yes
24BH0513	2007	Yes
24BH0514	2007	Yes
24BH0515	2007	Yes
24BH0516	2007	Yes
24BH0517	2007	Yes
24BH0518	2007	Yes
24BH0519	2007	Yes
24BH0520	2007	Yes
24BH0521	2007	Yes
24BH0522	2007	Yes
24BH407	2000	Yes
24BH408	2000	Yes
24BH409	2000	Yes
24BH410	2000	Yes
24BH411	2000	Yes
24BH412	2000	Yes
24BH413	2000	Yes
24BH414	2000	Yes

Table O-5
PFSA Soil Data Summary
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Location	Year Sampled	VOC Compound Detected?
24BH415	2000	Yes
24BH416	2000	Yes
24BH418	2000	Yes
24BH419	2000	Yes
24BH420	2000	Yes
24BH421	2000	Yes
24BH422	2000	Yes
24BH423	2000	Yes
24BH424	2000	Yes
24BH425	2000	Yes
24BH7300	2001	Yes
24BH7301	2001	Yes
24BH7302	2001	Yes
24BH7303	2001	Yes
24BH7304	2001	Yes
24BH7305	2001	Yes
24BH7306	2001	Yes
24BH7307	2001	Yes
24BH7308	2001	Yes
24BH7321	2001	Yes
24BH7322	2001	Yes
24BH7323	2001	Yes
24BH7324	2001	Yes
24BH7325	2001	Yes
24BH7327	2001	Yes
24BH7328	2001	Yes
24BHA1-06	2006	Yes
24BHB1	2005	Yes
24BHB2	2005	Yes
24BHB2-06	2006	Yes
24BHB3	2005	Yes
24BHB4	2005	Yes
24BHB7	2005	Yes
24BHB9	2005	Yes
24BHC1	2005	Yes
24BHC2-06	2006	Yes
24BHC3	2005	Yes
24BHC4	2005	Yes
24BHC4-06	2006	Yes
24BHC6	2005	Yes
24BHC7	2005	Yes
24BHC7300	2001	Yes

Table O-5
PFSA Soil Data Summary
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Location	Year Sampled	VOC Compound Detected?
24BHC7301	2001	Yes
24BHC8	2005	Yes
24BHC9	2005	Yes
24BHD2	2005	Yes
24BHD3	2005	Yes
24BHD3-06	2006	Yes
24BHD4	2005	Yes
24BHD6	2005	Yes
24BHD7	2005	Yes
24BHD8	2005	Yes
24BHD9	2005	Yes
24BHE1	2005	Yes
24BHE2	2005	Yes
24BHE3-06	2006	Yes
24BHE4	2005	Yes
24BHE4-06	2006	Yes
24BHE6	2005	Yes
24BHE9	2005	Yes
24BHF2-06	2006	Yes
24BHF3	2005	Yes
24BHF3-06	2006	Yes
24BHF4-06	2006	Yes
24BHG4-06	2006	Yes
24BHS1	2003	Yes
24BHS2	2003	Yes
24BHS3	2003	Yes
24DP400	2000	Yes
24DP402	2000	Yes
24DP404	2000	Yes
24DP426	2000	Yes
24DP427	2000	Yes
24DP428	2000	Yes
24DP429	2000	Yes
24DP430	2000	Yes
24DP433	2000	Yes
24DP435	2000	Yes
24DP436	2000	Yes
24IW412	2001	Yes
24PE1	2004	Yes
24PE10	2003	Yes
24PE11	2003	Yes
24PE12	2003	Yes

Table O-5
PFSA Soil Data Summary
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Location	Year Sampled	VOC Compound Detected?
24PE13	2004	Yes
24PE14	2004	Yes
24PE15	2004	Yes
24PE16	2004	Yes
24PE17	2004	Yes
24PE2	2003	Yes
24PE3	2003	Yes
24PE4	2003	Yes
24PE5	2003	Yes
24PE6	2003	Yes
24PE7	2003	Yes
24PE8	2004	Yes
24PE9	2003	Yes
MW18	2003	Yes

Data Source: AFCEE, April 2011, MMR-AFCEE Data Warehouse

Key:

VOC = volatile organic compound

Table O-6
Detected Concentrations In PFSA Soil Within 100 Feet of Occupied Buildings
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Location Identification	Sample Date	Sample Depth (ft bgs)	Volatile Compound	Result (µg/kg)	DL (µg/kg)	RL (µg/kg)
24BH408	9/26/2000	49	ETHYLBENZENE	BRL	0.26	4.7
24BH408	9/26/2000	51	ETHYLBENZENE	BRL	0.29	5.2
24BH408	9/26/2000	53	ETHYLBENZENE	BRL	0.3	5.4
24BH408	9/26/2000	55	ETHYLBENZENE	BRL	0.24	4.4
24BH408	9/26/2000	55	M,P-XYLENE (SUM OF ISOMERS)	30.2	0.66	4.4
24BH408	9/26/2000	55	O-XYLENE (1,2-DIMETHYLBENZENE)	21.9	0.29	4.4
24BH408	9/26/2000	57	ETHYLBENZENE	14.3	0.25	4.4
24BH408	9/26/2000	57	M,P-XYLENE (SUM OF ISOMERS)	73.8	0.67	4.4
24BH408	9/26/2000	57	O-XYLENE (1,2-DIMETHYLBENZENE)	56.2	0.29	4.4
24BH408	9/26/2000	59	ETHYLBENZENE	12.4	0.24	4.3
24BH408	9/26/2000	59	M,P-XYLENE (SUM OF ISOMERS)	65.5	0.66	4.3
24BH408	9/26/2000	59	O-XYLENE (1,2-DIMETHYLBENZENE)	44.6	0.29	4.3
24BH408	9/26/2000	61	ETHYLBENZENE	11.8	0.25	4.4
24BH408	9/26/2000	61	M,P-XYLENE (SUM OF ISOMERS)	48.2	0.67	4.4
24BH408	9/26/2000	61	O-XYLENE (1,2-DIMETHYLBENZENE)	26.4	0.29	4.4
24BH408	9/26/2000	63	ETHYLBENZENE	4.3	0.24	4.3
24BH408	9/26/2000	63	M,P-XYLENE (SUM OF ISOMERS)	18.8	0.67	4.3
24BH408	9/26/2000	63	O-XYLENE (1,2-DIMETHYLBENZENE)	10	0.31	4.3
24BH412	10/10/2000	49	M,P-XYLENE (SUM OF ISOMERS)	BRL	0.75	4.9
24BH412	10/10/2000	49	O-XYLENE (1,2-DIMETHYLBENZENE)	BRL	0.33	4.9
24BH412	10/10/2000	51	M,P-XYLENE (SUM OF ISOMERS)	BRL	0.72	4.7
24BH412	10/10/2000	51	O-XYLENE (1,2-DIMETHYLBENZENE)	BRL	0.31	4.7
24BH412	10/10/2000	53	M,P-XYLENE (SUM OF ISOMERS)	BRL	0.77	5.1
24BH412	10/10/2000	53	O-XYLENE (1,2-DIMETHYLBENZENE)	BRL	0.33	5.1
24BH412	10/10/2000	55	ETHYLBENZENE	1,170	12.7	227
24BH412	10/10/2000	55	M,P-XYLENE (SUM OF ISOMERS)	7,530	34.6	227
24BH412	10/10/2000	55	O-XYLENE (1,2-DIMETHYLBENZENE)	2,450	15	227
24BH412	10/10/2000	57	ETHYLBENZENE	38.3	0.26	4.6
24BH412	10/10/2000	57	M,P-XYLENE (SUM OF ISOMERS)	189	0.69	4.6
24BH412	10/10/2000	57	O-XYLENE (1,2-DIMETHYLBENZENE)	100	0.3	4.6
24BH412	10/10/2000	59	ETHYLBENZENE	34.8	0.25	4.5
24BH412	10/10/2000	59	M,P-XYLENE (SUM OF ISOMERS)	174	0.68	4.5
24BH412	10/10/2000	59	O-XYLENE (1,2-DIMETHYLBENZENE)	94.8	0.29	4.5
24BH412	10/10/2000	61	ETHYLBENZENE	20.8	0.24	4.3
24BH412	10/10/2000	61	M,P-XYLENE (SUM OF ISOMERS)	99.5	0.66	4.3
24BH412	10/10/2000	61	O-XYLENE (1,2-DIMETHYLBENZENE)	53.9	0.29	4.3
24BH412	10/10/2000	63	ETHYLBENZENE	37.1	0.26	4.6
24BH412	10/10/2000	63	M,P-XYLENE (SUM OF ISOMERS)	186	0.7	4.6
24BH412	10/10/2000	63	O-XYLENE (1,2-DIMETHYLBENZENE)	91.8	0.3	4.6
24BH412	10/10/2000	65	ETHYLBENZENE	27	0.25	4.5
24BH412	10/10/2000	65	M,P-XYLENE (SUM OF ISOMERS)	128	0.69	4.5
24BH412	10/10/2000	65	O-XYLENE (1,2-DIMETHYLBENZENE)	66.1	0.3	4.5
24BH412	10/10/2000	67	ETHYLBENZENE	BRL	0.25	4.5
24BH412	10/10/2000	67	M,P-XYLENE (SUM OF ISOMERS)	17.9	0.68	4.5
24BH412	10/10/2000	67	O-XYLENE (1,2-DIMETHYLBENZENE)	8.5	0.29	4.5
24BH412	10/10/2000	69	ETHYLBENZENE	BRL	0.25	4.4

Table O-6
Detected Concentrations In PFSA Soil Within 100 Feet of Occupied Buildings
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Location Identification	Sample Date	Sample Depth (ft bgs)	Volatile Compound	Result (µg/kg)	DL (µg/kg)	RL (µg/kg)
24BH412	10/10/2000	69	M,P-XYLENE (SUM OF ISOMERS)	11.3	0.67	4.4
24BH412	10/10/2000	69	O-XYLENE (1,2-DIMETHYLBENZENE)	5.5	0.29	4.4
24BH415	10/11/2000	49	ETHYLBENZENE	BRL	0.27	4.8
24BH415	10/11/2000	49	M,P-XYLENE (SUM OF ISOMERS)	BRL	0.73	4.8
24BH415	10/11/2000	49	O-XYLENE (1,2-DIMETHYLBENZENE)	BRL	0.32	4.8
24BH415	10/11/2000	51	ETHYLBENZENE	BRL	0.3	5.3
24BH415	10/11/2000	51	M,P-XYLENE (SUM OF ISOMERS)	BRL	0.81	5.3
24BH415	10/11/2000	51	O-XYLENE (1,2-DIMETHYLBENZENE)	BRL	0.35	5.3
24BH415	10/11/2000	53	ETHYLBENZENE	BRL	0.28	5
24BH415	10/11/2000	53	M,P-XYLENE (SUM OF ISOMERS)	BRL	0.76	5
24BH415	10/11/2000	53	O-XYLENE (1,2-DIMETHYLBENZENE)	BRL	0.33	5
24BH415	10/11/2000	55	M,P-XYLENE (SUM OF ISOMERS)	BRL	0.73	4.8
24BH415	10/11/2000	55	O-XYLENE (1,2-DIMETHYLBENZENE)	BRL	0.32	4.8
24BH415	10/11/2000	57	M,P-XYLENE (SUM OF ISOMERS)	BRL	0.67	4.4
24BH415	10/11/2000	57	O-XYLENE (1,2-DIMETHYLBENZENE)	BRL	0.29	4.4
24BH415	10/11/2000	59	ETHYLBENZENE	BRL	0.24	4.3
24BH415	10/11/2000	59	M,P-XYLENE (SUM OF ISOMERS)	BRL	0.65	4.3
24BH415	10/11/2000	59	O-XYLENE (1,2-DIMETHYLBENZENE)	BRL	0.28	4.3
24BH415	10/11/2000	61	M,P-XYLENE (SUM OF ISOMERS)	BRL	0.7	4.6
24BH415	10/11/2000	61	O-XYLENE (1,2-DIMETHYLBENZENE)	BRL	0.31	4.6
24BH415	10/11/2000	65	ETHYLBENZENE	BRL	0.26	4.6
24BH415	10/11/2000	65	M,P-XYLENE (SUM OF ISOMERS)	BRL	0.7	4.6
24BH415	10/11/2000	65	O-XYLENE (1,2-DIMETHYLBENZENE)	BRL	0.3	4.6
24BH415	10/11/2000	67	ETHYLBENZENE	BRL	0.24	4.4
24BH415	10/11/2000	67	M,P-XYLENE (SUM OF ISOMERS)	BRL	0.66	4.4
24BH415	10/11/2000	67	O-XYLENE (1,2-DIMETHYLBENZENE)	BRL	0.29	4.4
24BHD2	6/10/2005	53	ACETONE	16	3.7	12
24BHD2	6/10/2005	53	CARBON DISULFIDE	BRL	0.46	4.7
24BHD2	6/10/2005	53	TOLUENE	BRL	0.52	4.7
24BHD2	6/10/2005	58	ACETONE	BRL	3.7	12
24BHD2	6/10/2005	58	C5-C8 ALIPHATIC HYDROCARBONS	300,000	6.3	25.7
24BHD2	6/10/2005	58	C9-C10 AROMATIC HYDROCARBONS	220,000	6.43	12.9
24BHD2	6/10/2005	58	C9-C12 ALIPHATIC HYDROCARBONS	360,000	6.43	19.3
24BHD2	6/10/2005	58	C9-C18 ALIPHATIC HYDROCARBONS	116,000	12.4	46.4
24BHD2	6/10/2005	58	CARBON DISULFIDE	BRL	0.46	4.8
24BHD2	6/10/2005	58	CYCLOHEXANE	6	0.91	4.8
24BHD2	6/10/2005	58	ETHYLBENZENE	26	0.78	4.8
24BHD2	6/10/2005	58	ISOPROPYLBENZENE (CUMENE)	210E	1.2	4.8
24BHD2	6/10/2005	58	M,P-XYLENE (SUM OF ISOMERS)	2,680	1.29	2.57
24BHD2	6/10/2005	58	METHYLCYCLOHEXANE	530E	1.7	4.8
24BHD2	6/10/2005	58	NAPHTHALENE	4,950	0.64	1.29
24BHD2	6/10/2005	58	O-XYLENE (1,2-DIMETHYLBENZENE)	1,320	0.64	1.29
24BHD2	6/10/2005	58	XYLENES, TOTAL	1,400E	1.3	14
24BHD2	6/10/2005	63	TOLUENE	BRL	0.52	4.5
24BHD3-06	9/13/2006	54.5	2-METHYLNAPHTHALENE	8,500	560	560
24BHD3-06	9/13/2006	54.5	BENZENE	1,100JS	460	460

Table O-6
Detected Concentrations In PFSA Soil Within 100 Feet of Occupied Buildings
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Location Identification	Sample Date	Sample Depth (ft bgs)	Volatile Compound	Result (µg/kg)	DL (µg/kg)	RL (µg/kg)
24BHD3-06	9/13/2006	54.5	C11-C22 AROMATIC HYDROCARBONS	230,000J	34,000	34,000
24BHD3-06	9/13/2006	54.5	C5-C8 ALIPHATIC HYDROCARBONS	880,000J	4,600	4,600
24BHD3-06	9/13/2006	54.5	C9-C10 AROMATIC HYDROCARBONS	670,000J	4,600	4,600
24BHD3-06	9/13/2006	54.5	C9-C12 ALIPHATIC HYDROCARBONS	250,000J	4,600	4,600
24BHD3-06	9/13/2006	54.5	C9-C18 ALIPHATIC HYDROCARBONS	1,500,000J	34,000	34,000
24BHD3-06	9/13/2006	54.5	ETHYLBENZENE	24	0.72	5.4
24BHD3-06	9/13/2006	54.5	ETHYLBENZENE	13,000JS	460	460
24BHD3-06	9/13/2006	54.5	M,P-XYLENE (SUM OF ISOMERS)	110J	1.1	11
24BHD3-06	9/13/2006	54.5	M,P-XYLENE (SUM OF ISOMERS)	24,000JS	460	460
24BHD3-06	9/13/2006	54.5	NAPHTHALENE	3,200J	560	560
24BHD3-06	9/13/2006	54.5	NAPHTHALENE	33,000JS	2,300	2,300
24BHD3-06	9/13/2006	54.5	O-XYLENE (1,2-DIMETHYLBENZENE)	79J	0.65	5.4
24BHD3-06	9/13/2006	54.5	O-XYLENE (1,2-DIMETHYLBENZENE)	14,000JS	460	460
24BHD3-06	9/13/2006	54.5	TOLUENE	1,900JS	460	460
24BHE1	6/9/2005	53	ACETONE	BRL	3.7	11
24BHE1	6/9/2005	53	TOLUENE	BRL	0.52	4.3
24BHE1	6/9/2005	58	C11-C22 AROMATIC HYDROCARBONS	37,200	9.57	35.9
24BHE1	6/9/2005	58	C11-C22 AROMATIC HYDROCARBONS	42,300	10.9	40.8
24BHE1	6/9/2005	58	C5-C8 ALIPHATIC HYDROCARBONS	664,000	6.16	25.2
24BHE1	6/9/2005	58	C5-C8 ALIPHATIC HYDROCARBONS	141,000	6.54	26.7
24BHE1	6/9/2005	58	C9-C10 AROMATIC HYDROCARBONS	271,000	6.29	12.6
24BHE1	6/9/2005	58	C9-C10 AROMATIC HYDROCARBONS	102,000	6.67	13.3
24BHE1	6/9/2005	58	C9-C12 ALIPHATIC HYDROCARBONS	500,000	6.29	18.9
24BHE1	6/9/2005	58	C9-C12 ALIPHATIC HYDROCARBONS	205,000	6.67	20
24BHE1	6/9/2005	58	C9-C18 ALIPHATIC HYDROCARBONS	352,000	10.9	40.8
24BHE1	6/9/2005	58	M,P-XYLENE (SUM OF ISOMERS)	3,000	1.26	2.52
24BHE1	6/9/2005	58	NAPHTHALENE	5,760	0.63	1.26
24BHE1	6/9/2005	58	NAPHTHALENE	1,830	0.67	1.33
24BHE1	6/9/2005	58	O-XYLENE (1,2-DIMETHYLBENZENE)	2,050	0.63	1.26
24BHE1	6/9/2005	58	TOLUENE	BRL	0.52	91
24BHE1	6/9/2005	63	ACETONE	BRL	3.7	14
24BHE1	6/9/2005	63	TOLUENE	BRL	0.52	5.6
24BHE2	6/8/2005	53	ACETONE	BRL	3.7	13
24BHE2	6/8/2005	53	CYCLOHEXANE	16	0.91	5.3
24BHE2	6/8/2005	53	TOLUENE	BRL	0.52	5.3
24BHE2	6/8/2005	58	ACETONE	BRL	3.7	13
24BHE2	6/8/2005	58	CYCLOHEXANE	BRL	0.91	5.1
24BHE2	6/8/2005	58	TOLUENE	BRL	0.52	5.1
24BHE2	6/8/2005	63	ACETONE	BRL	3.7	11
24BHE2	6/8/2005	63	TOLUENE	BRL	0.52	4.4
24BHE3-06	9/12/2006	55	C5-C8 ALIPHATIC HYDROCARBONS	540,000	23,000	23,000
24BHE3-06	9/12/2006	55	C9-C10 AROMATIC HYDROCARBONS	600,000	23,000	23,000
24BHE3-06	9/12/2006	55	C9-C12 ALIPHATIC HYDROCARBONS	360,000	23,000	23,000
24BHE3-06	9/12/2006	55	ETHYLBENZENE	11,000S	2,300	2,300
24BHE3-06	9/12/2006	55	M,P-XYLENE (SUM OF ISOMERS)	3,200S	2,300	2,300
24BHE3-06	9/12/2006	55	NAPHTHALENE	33,000S	12,000	12,000

Table O-6
Detected Concentrations In PFSA Soil Within 100 Feet of Occupied Buildings
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Location Identification	Sample Date	Sample Depth (ft bgs)	Volatile Compound	Result (µg/kg)	DL (µg/kg)	RL (µg/kg)
24BHE3-06	9/12/2006	55	O-XYLENE (1,2-DIMETHYLBENZENE)	2,500S	2,300	2,300
24BHE3-06	9/13/2006	59	C5-C8 ALIPHATIC HYDROCARBONS	17,000	1,200	1,200
24BHE3-06	9/13/2006	59	C9-C10 AROMATIC HYDROCARBONS	46,000	1,200	1,200
24BHE3-06	9/13/2006	59	C9-C12 ALIPHATIC HYDROCARBONS	32,000	1,200	1,200
24BHE3-06	9/13/2006	59	ETHYLBENZENE	420S	120	120
24BHE3-06	9/13/2006	59	M,P-XYLENE (SUM OF ISOMERS)	200S	120	120
24BHE3-06	9/13/2006	59	NAPHTHALENE	2,600S	600	600
24BHF2-06	10/3/2006	58.5	C9-C10 AROMATIC HYDROCARBONS	2,200	1,300	1,300
24BHF2-06	10/3/2006	58.5	C9-C12 ALIPHATIC HYDROCARBONS	1,600	1,300	1,300
24BHF3	6/7/2005	53	ACETONE	BRL	3.7	13
24BHF3	6/7/2005	53	CARBON DISULFIDE	BRL	0.46	5.1
24BHF3	6/7/2005	53	METHYL ETHYL KETONE (2-BUTANONE)	BRL	1.9	13
24BHF3	6/7/2005	53	TOLUENE	BRL	0.52	5.1
24BHF3	6/7/2005	58	ACETONE	15	3.7	14
24BHF3	6/7/2005	58	BENZENE	BRL	0.51	5.7
24BHF3	6/7/2005	58	C9-C10 AROMATIC HYDROCARBONS	98,600	8.12	16.2
24BHF3	6/7/2005	58	C9-C12 ALIPHATIC HYDROCARBONS	208,000	8.12	24.4
24BHF3	6/7/2005	58	C9-C18 ALIPHATIC HYDROCARBONS	100,000	24.9	49.8
24BHF3	6/7/2005	58	CHLOROMETHANE	BRL	0.37	5.7
24BHF3	6/7/2005	58	ETHYLBENZENE	BRL	0.78	5.7
24BHF3	6/7/2005	58	METHYL ETHYL KETONE (2-BUTANONE)	BRL	1.9	14
24BHF3	6/7/2005	58	TOLUENE	BRL	0.52	5.7
24BHF3	6/7/2005	58	XYLENES, TOTAL	BRL	1.3	17
24BHF3	6/7/2005	63	ACETONE	BRL	3.7	13
24BHF3	6/7/2005	63	CYCLOHEXANE	BRL	0.91	5.4
24BHF3	6/7/2005	63	TOLUENE	BRL	0.52	5.4
24BHF3-06	9/28/2006	53.5	C9-C10 AROMATIC HYDROCARBONS	1,500	1,100	1,100
24BHF3-06	9/28/2006	53.5	ETHYLBENZENE	BRL	0.65	4.9
24BHF3-06	9/28/2006	53.5	O-XYLENE (1,2-DIMETHYLBENZENE)	BRL	0.6	4.9
24BHF4-06	9/11/2006	58	O-XYLENE (1,2-DIMETHYLBENZENE)	120S	120	120
24BHG4-06	9/6/2006	55	2-METHYLNAPHTHALENE	1,600	570	570
24BHG4-06	9/6/2006	55	C11-C22 AROMATIC HYDROCARBONS	45,000	34,000	34,000
24BHG4-06	9/6/2006	55	C5-C8 ALIPHATIC HYDROCARBONS	450,000	5,100	5,100
24BHG4-06	9/6/2006	55	C9-C10 AROMATIC HYDROCARBONS	520,000	5,100	5,100
24BHG4-06	9/6/2006	55	C9-C12 ALIPHATIC HYDROCARBONS	200,000	5,100	5,100
24BHG4-06	9/6/2006	55	C9-C18 ALIPHATIC HYDROCARBONS	220,000	34,000	34,000
24BHG4-06	9/6/2006	55	ETHYLBENZENE	17	0.68	5.1
24BHG4-06	9/6/2006	55	ETHYLBENZENE	7,900S	510	510
24BHG4-06	9/6/2006	55	M,P-XYLENE (SUM OF ISOMERS)	160	1.1	10
24BHG4-06	9/6/2006	55	M,P-XYLENE (SUM OF ISOMERS)	6,100S	510	510
24BHG4-06	9/6/2006	55	NAPHTHALENE	9,500S	2,500	2,500
24BHG4-06	9/6/2006	55	O-XYLENE (1,2-DIMETHYLBENZENE)	55	0.62	5.1
24BHG4-06	9/6/2006	55	O-XYLENE (1,2-DIMETHYLBENZENE)	3,200S	510	510
24BHG4-06	9/6/2006	55	TOLUENE	1,200S	510	510
24BHS1	1/22/2003	53	ACETONE	BRL	0.8	11
24BHS1	1/22/2003	53	BENZENE	BRL	0.3	4
24BHS1	1/22/2003	53	ETHYLBENZENE	BRL	0.3	4

Table O-6
Detected Concentrations In PFSA Soil Within 100 Feet of Occupied Buildings
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Location Identification	Sample Date	Sample Depth (ft bgs)	Volatile Compound	Result (µg/kg)	DL (µg/kg)	RL (µg/kg)
24BHS1	1/22/2003	53	METHYLENE CHLORIDE	BRL	0.4	4
24BHS1	1/22/2003	53	tert-BUTYL METHYL ETHER	BRL	0.3	4
24BHS1	1/22/2003	53	TOLUENE	6	0.3	4
24BHS1	1/22/2003	53	XYLENES, TOTAL	BRL	0.01	13
24BHS1	1/22/2003	55	ACETONE	BRL	0.8	11
24BHS1	1/22/2003	55	BENZENE	BRL	0.3	5
24BHS1	1/22/2003	55	ETHYLBENZENE	BRL	0.3	5
24BHS1	1/22/2003	55	tert-BUTYL METHYL ETHER	BRL	0.3	5
24BHS1	1/22/2003	55	TOLUENE	5	0.3	5
24BHS1	1/22/2003	55	XYLENES, TOTAL	BRL	0.01	14
24BHS1	1/23/2003	56.5	ACETONE	BRL	0.8	11
24BHS1	1/23/2003	56.5	BENZENE	BRL	0.3	4
24BHS1	1/23/2003	56.5	ETHYLBENZENE	BRL	0.3	4
24BHS1	1/23/2003	56.5	tert-BUTYL METHYL ETHER	BRL	0.3	4
24BHS1	1/23/2003	56.5	TOLUENE	5	0.3	4
24BHS1	1/23/2003	56.5	XYLENES, TOTAL	BRL	0.01	13
24BHS2	1/27/2003	53	ACETONE	BRL	0.8	11
24BHS2	1/27/2003	53	CYCLOHEXANE	BRL	0.4	4
24BHS2	1/27/2003	53	TOLUENE	BRL	0.3	4
24BHS2	1/27/2003	53	XYLENES, TOTAL	BRL	0.01	13
24BHS2	1/27/2003	55	ACETONE	BRL	0.8	11
24BHS2	1/27/2003	55	TOLUENE	BRL	0.3	4
24BHS2	1/27/2003	55	XYLENES, TOTAL	BRL	0.01	13
24BHS2	1/27/2003	57	ACETONE	BRL	0.8	12
24BHS2	1/27/2003	57	ETHYLBENZENE	BRL	0.3	5
24BHS2	1/27/2003	57	TOLUENE	BRL	0.3	5
24BHS2	1/27/2003	57	XYLENES, TOTAL	BRL	0.01	14
24DP426	10/17/2000	61	M,P-XYLENE (SUM OF ISOMERS)	BRL	0.69	4.5
24DP426	10/17/2000	65	M,P-XYLENE (SUM OF ISOMERS)	BRL	0.71	4.7
24DP427	10/17/2000	49	M,P-XYLENE (SUM OF ISOMERS)	BRL	0.8	5.3
24DP427	10/17/2000	49	O-XYLENE (1,2-DIMETHYLBENZENE)	BRL	0.35	5.3
24DP427	10/17/2000	51	M,P-XYLENE (SUM OF ISOMERS)	BRL	0.76	5
24DP427	10/17/2000	51	O-XYLENE (1,2-DIMETHYLBENZENE)	BRL	0.33	5
24DP427	10/17/2000	53	M,P-XYLENE (SUM OF ISOMERS)	BRL	0.77	5.1
24DP427	10/17/2000	53	O-XYLENE (1,2-DIMETHYLBENZENE)	BRL	0.33	5.1
24DP427	10/17/2000	55	ETHYLBENZENE	BRL	0.27	4.8
24DP427	10/17/2000	55	M,P-XYLENE (SUM OF ISOMERS)	BRL	0.73	4.8
24DP427	10/17/2000	55	O-XYLENE (1,2-DIMETHYLBENZENE)	BRL	0.32	4.8
24DP427	10/17/2000	57	ETHYLBENZENE	BRL	10.8	193
24DP427	10/17/2000	57	M,P-XYLENE (SUM OF ISOMERS)	567	29.3	193
24DP427	10/17/2000	57	O-XYLENE (1,2-DIMETHYLBENZENE)	262	12.7	193
24DP427	10/17/2000	59	M,P-XYLENE (SUM OF ISOMERS)	BRL	0.71	4.7
24DP427	10/17/2000	59	O-XYLENE (1,2-DIMETHYLBENZENE)	BRL	0.31	4.7
24DP428	10/18/2000	33	ETHYLBENZENE	BRL	0.29	5.1
24DP428	10/18/2000	33	M,P-XYLENE (SUM OF ISOMERS)	BRL	0.78	5.1
24DP428	10/18/2000	33	O-XYLENE (1,2-DIMETHYLBENZENE)	BRL	0.34	5.1
24DP428	10/18/2000	35	ETHYLBENZENE	BRL	0.3	5.3
24DP428	10/18/2000	35	M,P-XYLENE (SUM OF ISOMERS)	BRL	0.81	5.3
24DP428	10/18/2000	35	O-XYLENE (1,2-DIMETHYLBENZENE)	BRL	0.35	5.3

Table O-6
Detected Concentrations In PFSA Soil Within 100 Feet of Occupied Buildings
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Location Identification	Sample Date	Sample Depth (ft bgs)	Volatile Compound	Result (µg/kg)	DL (µg/kg)	RL (µg/kg)
24DP428	10/18/2000	37	ETHYLBENZENE	BRL	0.28	5
24DP428	10/18/2000	37	M,P-XYLENE (SUM OF ISOMERS)	BRL	0.77	5
24DP428	10/18/2000	37	O-XYLENE (1,2-DIMETHYLBENZENE)	BRL	0.33	5
24DP428	10/18/2000	39	M,P-XYLENE (SUM OF ISOMERS)	BRL	0.76	5
24DP428	10/18/2000	39	O-XYLENE (1,2-DIMETHYLBENZENE)	BRL	0.33	5
24DP428	10/18/2000	41	ETHYLBENZENE	23,900	0.25	4.5
24DP428	10/18/2000	41	ETHYLBENZENE	BRL	13.5	240
24DP428	10/18/2000	41	M,P-XYLENE (SUM OF ISOMERS)	45,600	0.68	4.5
24DP428	10/18/2000	41	O-XYLENE (1,2-DIMETHYLBENZENE)	1,790	0.3	4.5
24DP428	10/18/2000	41	O-XYLENE (1,2-DIMETHYLBENZENE)	BRL	15.9	240
24DP428	10/18/2000	43	ETHYLBENZENE	1,350	7.9	141
24DP428	10/18/2000	43	M,P-XYLENE (SUM OF ISOMERS)	6,920	21.4	141
24DP428	10/18/2000	43	O-XYLENE (1,2-DIMETHYLBENZENE)	1,650	9.3	141
24DP428	10/18/2000	45	ETHYLBENZENE	2,310	15	268
24DP428	10/18/2000	45	M,P-XYLENE (SUM OF ISOMERS)	14,400	40.7	268
24DP428	10/18/2000	45	O-XYLENE (1,2-DIMETHYLBENZENE)	359	17.7	268
24DP428	10/18/2000	47	ETHYLBENZENE	BRL	0.24	4.3
24DP428	10/18/2000	47	M,P-XYLENE (SUM OF ISOMERS)	BRL	0.66	4.3
24DP428	10/18/2000	47	O-XYLENE (1,2-DIMETHYLBENZENE)	BRL	0.29	4.3
24DP428	10/18/2000	51	ETHYLBENZENE	BRL	0.26	4.6
24DP428	10/18/2000	51	M,P-XYLENE (SUM OF ISOMERS)	6.9	0.71	4.6
24DP428	10/18/2000	51	O-XYLENE (1,2-DIMETHYLBENZENE)	BRL	0.31	4.6
24DP429	11/17/2000	57	ETHYLBENZENE	BRL	12.5	223
24DP429	11/17/2000	57	M,P-XYLENE (SUM OF ISOMERS)	BRL	33.8	223
24DP429	11/17/2000	61	M,P-XYLENE (SUM OF ISOMERS)	BRL	21.9	144
24IW412	7/24/2001	49	C11-C22 AROMATIC HYDROCARBONS	2,690	1,250	2,500
24IW412	7/24/2001	51	C11-C22 AROMATIC HYDROCARBONS	4,340	1,250	2,500
24IW412	7/24/2001	53	C11-C22 AROMATIC HYDROCARBONS	4,030	1,250	2,500
24IW412	7/24/2001	55	C11-C22 AROMATIC HYDROCARBONS	5,660	1,375	2,750
24IW412	7/24/2001	55	C19-C36 ALIPHATIC HYDROCARBONS	3,720	1,375	2,750
24IW412	7/24/2001	55	C9-C12 ALIPHATIC HYDROCARBONS	5,020	1,150	2,300
24IW412	7/24/2001	57	2-METHYLNAPHTHALENE	4,130	125	250
24IW412	7/24/2001	57	C11-C22 AROMATIC HYDROCARBONS	68,500	1,500	3,000
24IW412	7/24/2001	57	C11-C22 AROMATIC HYDROCARBONS	132,000J	1,575	3,150
24IW412	7/24/2001	57	C11-C22 AROMATIC HYDROCARBONS	134,000	2,500	5,000
24IW412	7/24/2001	57	C19-C36 ALIPHATIC HYDROCARBONS	11,000	1,500	3,000
24IW412	7/24/2001	57	C19-C36 ALIPHATIC HYDROCARBONS	8,050	1,575	3,150
24IW412	7/24/2001	57	C5-C8 ALIPHATIC HYDROCARBONS	822,000J	1,500	3,000
24IW412	7/24/2001	57	C5-C8 ALIPHATIC HYDROCARBONS	1,120,000J	560,000	1,120,000
24IW412	7/24/2001	57	C9-C10 AROMATIC HYDROCARBONS	96,700J	1,500	3,000
24IW412	7/24/2001	57	C9-C12 ALIPHATIC HYDROCARBONS	838,000J	1,500	3,000
24IW412	7/24/2001	57	C9-C12 ALIPHATIC HYDROCARBONS	2,800,000	560,000	1,120,000
24IW412	7/24/2001	57	C9-C18 ALIPHATIC HYDROCARBONS	398,000J	1,500	3,000
24IW412	7/24/2001	57	C9-C18 ALIPHATIC HYDROCARBONS	880,000J	1,575	3,150
24IW412	7/24/2001	57	C9-C18 ALIPHATIC HYDROCARBONS	486,000	28,750	57,500
24IW412	7/24/2001	57	C9-C18 ALIPHATIC HYDROCARBONS	1,250,000	62,500	125,000
24IW412	7/24/2001	57	ETHYLBENZENE	2,360	60	120
24IW412	7/24/2001	57	M,P-XYLENE (SUM OF ISOMERS)	11,400	240	480
24IW412	7/24/2001	57	NAPHTHALENE	5,600	60	120

Table O-6
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Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Location Identification	Sample Date	Sample Depth (ft bgs)	Volatile Compound	Result (µg/kg)	DL (µg/kg)	RL (µg/kg)
24IW412	7/24/2001	57	NAPHTHALENE	837	120	240
24IW412	7/24/2001	57	NAPHTHALENE	2,270	125	250
24IW412	7/24/2001	57	O-XYLENE (1,2-DIMETHYLBENZENE)	5,170	120	240
24IW412	7/24/2001	59	C11-C22 AROMATIC HYDROCARBONS	3,100	1,375	2,750
24IW412	7/24/2001	59	C5-C8 ALIPHATIC HYDROCARBONS	136,000J	1,250	2,500
24IW412	7/24/2001	59	C5-C8 ALIPHATIC HYDROCARBONS	257,000J	128,500	257,000
24IW412	7/24/2001	59	C9-C10 AROMATIC HYDROCARBONS	16,100J	1,250	2,500
24IW412	7/24/2001	59	C9-C12 ALIPHATIC HYDROCARBONS	257,000J	1,250	2,500
24IW412	7/24/2001	59	C9-C12 ALIPHATIC HYDROCARBONS	462,000	128,500	257,000
24IW412	7/24/2001	59	C9-C18 ALIPHATIC HYDROCARBONS	15,100	1,375	2,750
24IW412	7/24/2001	59	ETHYLBENZENE	473	50	100
24IW412	7/24/2001	59	M,P-XYLENE (SUM OF ISOMERS)	2,300	200	400
24IW412	7/24/2001	59	NAPHTHALENE	990	50	100
24IW412	7/24/2001	59	O-XYLENE (1,2-DIMETHYLBENZENE)	1,050	100	200
24IW412	7/24/2001	61	C19-C36 ALIPHATIC HYDROCARBONS	6,580	1,250	2,500
24IW412	7/24/2001	61	C5-C8 ALIPHATIC HYDROCARBONS	7,760	1,325	2,650
24IW412	7/24/2001	61	C9-C12 ALIPHATIC HYDROCARBONS	26,600J	1,325	2,650
24IW412	7/24/2001	61	C9-C12 ALIPHATIC HYDROCARBONS	32,100	6,400	12,800
24IW412	7/24/2001	61	C9-C18 ALIPHATIC HYDROCARBONS	4,270	1,250	2,500
24IW412	7/24/2001	61	M,P-XYLENE (SUM OF ISOMERS)	420J	210	420
24IW412	7/24/2001	61	O-XYLENE (1,2-DIMETHYLBENZENE)	210J	105	210
24IW412	7/24/2001	63	C5-C8 ALIPHATIC HYDROCARBONS	7,360	1,350	2,700
24IW412	7/24/2001	63	C9-C12 ALIPHATIC HYDROCARBONS	21,400J	1,350	2,700
24IW412	7/24/2001	63	C9-C12 ALIPHATIC HYDROCARBONS	27,900	6,800	13,600
24IW412	7/24/2001	63	M,P-XYLENE (SUM OF ISOMERS)	430J	215	430
24IW412	7/24/2001	65	C5-C8 ALIPHATIC HYDROCARBONS	2800J	1,400	2,800
24IW412	7/24/2001	65	C9-C12 ALIPHATIC HYDROCARBONS	4,810	1,400	2,800

Data Source: AFCEE, April 2011, MMR-AFCEE Data Warehouse

Note:

Data represent detections only in soil samples collected from locations within the 100-foot buffer zone of Buildings 561 and 587.

Key:

BRL = below reporting limit
DL = detection limit
E = concentration greater than instrument calibration range
ft bgs = feet below ground surface
J = estimated concentration
RL = reporting limit
S = screening level data
µg/kg = micrograms per kilogram

Table O-7
PSFA BSVR System Influent Vapor Data Summary
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

ZONE 1 INFLUENT				
Chemical		**6-Jul-05**	**27-Sep-05**	**27-Dec-05**
2,2,4-Trimethylpentane		1.4	130	34
Dichlorofluoromethane		2.7	--	3.4
Trichlorofluoromethane		1.5	1.2	1.5
Methyl ethyl ketone		1.5	--	--
Chloroform		1.1	--	--
Toluene		--	1.5	--
Tetrachloroethene		--	--	1.7
n-Hexane		--	4.0	--
ZONE 2 INFLUENT				
Chemical		**7-Jul-05**	**23-Sep-05**	**27-Dec-05**
2,2,4-Trimethylpentane		--	--	1.6
Dichlorofluoromethane		2.8	2.7	3.3
Trichlorofluoromethane		1.9	1.5	1.6
Methylene chloride		3.9	--	--
Methyl ethyl ketone		--	2.1	--
Chloroform		6.9	--	7.5
Toluene		1.1	--	--
2-Hexanone		24	--	--
n-Hexane		9.6	--	--
n-Heptane		7.0	--	--
ZONE 3 INFLUENT				
Chemical	**12-Mar-07**	**6-Jun-07**	**4-Sep-07**	**5-Dec-07**
2,2,4-Trimethylpentane	--	6.1	47	--
Dichlorofluoromethane	3.1	--	--	--
Trichlorofluoromethane	1.5	--	--	1.2
Methyl ethyl ketone	--	1.6	--	--
Tetrachloroethene	2.3	1.6	2.5	1.7
n-Hexane	--	8.1	4.2	--
Cyclohexane	--	1.9	2.7	--
n-Heptane	--	1.7	3.9	--
ZONE 4 INFLUENT				
Chemical	**13-Mar-07**	**6-Jun-07**	**5-Sep-07**	**5-Dec-07**
2,2,4-Trimethylpentane	100	44	75	4.7
Dichlorofluoromethane	3.6	--	--	2.9
Trichlorofluoromethane	1.5	--	--	1.2
Methyl ethyl ketone	6.3	1.9	--	--
Chloroform	--	5.9	17	4.9
n-Hexane	5.6	7	4.2	--
Cyclohexane	14	2.6	6.5	--

Table O-7
PSFA BSVR System Influent Vapor Data Summary
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

ZONE 5 INFLUENT

Chemical	12-Mar-07	7-Jun-07	5-Sep-07	6-Dec-07
2,2,4-Trimethylpentane	290	460	28	130
Dichlorofluoromethane	2.9	--	--	3
Trichlorofluoromethane	1.3	--	--	1.2
Chloroform	2.9	5.9	7.3	6.8
Tetrachloroethene	--	--	1.8	--
2-Hexanone	--	34	--	--
1,3,5-Trimethylbenzene	--	13	--	--
n-Hexane	3.1	23	--	--
Cyclohexane	4.5	11	--	1.7
n-Heptane	--	45	--	--

ZONE 6 INFLUENT

Chemical	9-Mar-07	7-Jun-07	6-Sep-07	6-Dec-07
2,2,4-Trimethylpentane	560	1,200	330	89
Dichlorofluoromethane	3.3	--	--	2.6
Trichlorofluoromethane	1.4	--	--	1.2
Chloroform	1.6	--	8.3	2.6
1,3,5-Trimethylbenzene	--	35	--	--
n-Hexane	2.6	46	4.2	--
Cyclohexane	6.9	18	4.5	1.2
n-Heptane	--	120	--	4.9

Notes:

BSVR = Biosparge/Soil Vapor Recovery

Concentrations reported in micrograms per cubic meter ($\mu g/m^3$)

-- = not detected

Samples were collected in Summa canisters and analyzed by U.S. Environmental Protection Agency Method TO-15.

Table reports detected compounds only - refer to MMR IRP QAPP (AFCEE 2011a) for full TO-15 analyte list and reporting limits

BSVR influent concentration data for Zones 1 and 2 data from *Petroleum Fuels Storage Area/Fuel Spill 10/Fuel Spill 11 (PFSA/FS-10/FS-11) Biosparge/Soil Vapor Recovery System 2005 Annual Report* , AFCEE 2007 (April). Note that the remediation system was turned off during the first quarter of 2005.

BSVR influent concentration data for Zones 3, 4, 5, and 6 from project note PFSAPN02272008: *Petroleum Fuels Storage Area/Fuel Spill 10/ Fuel Spill 11 (PFSA/FS-10/FS-11) October 2007 Groundwater Sampling Event Analysis & Optimization of the Biosparge/Soil Vapor Recovery (BSVR) System* , AFCEE 2008 (27 February 2008).

APPENDIX P

FTA-2 Vapor Intrusion Evaluation

TABLE OF CONTENTS

Figures

Tables

ACRONYMS AND ABBREVIATIONS

AVGAS	aviation gasoline
BSVR	biosparge and vapor recovery
bgs	below ground surface
COC	contaminant of concern
COPC	contaminant of potential concern
CSM	conceptual site model
EPA	U.S. Environmental Protection Agency
EPH	extractable petroleum hydrocarbons
FTA-2	Fire Training Area-2
ft	feet/foot
GW-1	Groundwater-1
JP-4	Jet Propulsion-4
LF-2	Landfill-2
LTM	long term monitoring
MassDEP	Massachusetts Department of Environmental Protection
MCP	Massachusetts Contingency Plan
MMR	Massachusetts Military Reservation
PFSA	Petroleum Fuel Storage Area
PVC	polyvinyl chloride
RI	remedial investigation
ROD	Record of Decision

ACRONYMS AND ABBREVIATIONS

S-1	Soil-1
SD-1	Storm Drain-1
SD-5	Storm Drain-5
STCL	Soil Target Cleanup Level
SVOC	semivolatile organic compound
UST	underground storage tank
VI	vapor intrusion
VOC	volatile organic compound
VPH	volatile petroleum hydrocarbons
µg/kg	micrograms per kilogram
µg/L	micrograms per liter
1,2,4-TMB	1,2,4-trimethylbenzene
1,3,5-TMB	1,3,5-trimethylbenzene

P1.0 FIRE TRAINING AREA-2 VAPOR INTRUSION EVALUATION

P1.1 CONCEPTUAL SITE MODEL

Fire Training Area-2 (FTA-2), which is situated within the boundary of the Landfill-2 (LF-2) site, is located adjacent to the southern end of Runway No. 5, within the flight line security area of Massachusetts Military Reservation (MMR) (Figure P-1 and Figure 1-2 of the main document). For the purposes of this vapor intrusion (VI) evaluation, the FTA-2 area is generally defined as land within and approximately 500 feet (ft) around the LF-2 boundary (Figure P-1). Beyond the 500-ft buffer is considered either outside the area of interest for LF-2 and FTA-2 or entails groundwater contamination associated with other sites that have undergone a VI evaluation, such as the Petroleum Fuel Storage Area (PFSA, Appendix O) or Storm Drain-5 (SD-5, Appendix N); both are shown on Figure 1-2 of the main document. The extent of the FTA-2 area evaluated for VI risk is comprised of FTA-2 and LF-2 and is collectively referred to as “the FTA-2 area” in this document. References solely to “FTA-2” (and not “the FTA-2 area”) refer specifically to the approximate extent of FTA-2 as shown on Figure P-1. Similarly, references to “LF-2” refer specifically to the approximate extent of LF-2 as shown on Figure P-1. It is also acknowledged that residual groundwater contamination that may have originated from the former Western Aquafarm site (now closed) is being managed as part of the FTA-2 area.

The FTA-2 area is west of the former SD-5 plume and northwest of the PFSA, portions of which are included on the field of view depicted on Figure P-1. In addition, the Western Aquafarm is located adjacent to the FTA-2 area to the north.

Elements of this CSM include a physical description of the FTA-2 area and vicinity (including infrastructure, operations, and geology/hydrogeology), followed by a chronology of the site assessment and remediation activities undertaken to address contamination. Finally, buildings and utilities near the FTA-2 area are described.

P1.2 DESCRIPTION OF FTA-2 AND VICINITY

The FTA-2 area is located on the southeast corner of the MMR in Sandwich, Massachusetts (Figure 1-2 of the main document). The FTA-2 area occupies approximately 11 acres and includes the FTA-2 site located on top of the LF-2 landfill area (Figure P-1).

Landfill operations at LF-2 began in approximately 1940 and were discontinued in 1944. LF-2 contains primarily solid waste (e.g., bottles, glass, ash, metal scrap, wood, concrete, and asphalt construction debris). However, analytical results from a test pit that was advanced approximately 350 ft north of the FTA-2 indicates the presence of localized areas of petroleum contaminated soil at LF-2 (ABB-ES 1996). The landfill was covered with fill material before fire training activities were conducted at FTA-2 from 1948 to 1956. FTA-2 may have received up to 7,000 gallons per year of waste oil and fuel, aviation gas (AVGAS), Jet Propulsion-4 (JP-4) fuel, and solvents, which were ignited during fire training exercises (ABB-ES 1996). Sand, asphalt, and concrete rubble fill were apparently placed in a drainage swale before, during, and after fire-training activities at FTA-2. The FTA-2 area was covered with additional soil following its abandonment in 1956.

Prior to landfilling in the 1940s, the topography of the FTA-2 area was characterized by a prominent north-south swale that connected to the current Storm Drain-1 (SD-1) drainage ditch just south of South Outer Road (Figure P-1). As a result of landfilling operations, the FTA-2 area no longer provided effective surface drainage. Storm water drainage pipes were installed to carry runoff southward from the large nearby paved areas to the north and west and are described below (Section P1.5). Surface soils consist of fill with construction debris and above-described solid waste to a depth of up to approximately 16 ft below ground surface (bgs) (ABB-ES 1996). Below that, subsurface soils are predominantly well-graded medium-grained sand with small amounts of fine- to coarse-grained sand, and traces of fine- to coarse-grained gravel, cobbles, and silt. Soils at the FTA-2 area are characteristic of typical glacial outwash comprising the Mashpee Pitted Plain (AFCEE 2003a).

The depth to groundwater varies spatially and temporally but is approximately 45 to 50 ft bgs throughout the FTA-2 area. The FTA-2 area is approximately 3,300 ft north of Ashumet Pond (Figure 1-2 of main document), and groundwater flows south from the FTA-2 area toward the northwest corner of the pond under a hydraulic gradient of approximately 0.0022. A U.S. Geological Survey pumping test estimated the hydraulic conductivity of the shallow portion of the aquifer at 380 ft per day; assuming a porosity of 0.3, groundwater flow velocities in the shallow portion of the aquifer in this area are estimated at 2 to 3 ft per day (AFCEE 2003a).

The Western Aquafarm is a closed site that is located adjacent to the FTA-2 area to the north. The Western Aquafarm formerly consisted of six 25,000-gallon underground storage tanks (USTs) that were used in the 1950s and 1960s to store and transfer AVGAS and JP-4. Fuel was transferred from the tanks by pumping water into the tanks to displace the fuel. To refill the tanks with fuel, the water was displaced and was discharged into an adjacent 1-acre basin (SD-5 Catchment Basin). At the time of site characterization in 1994, a plume of fuel-related compounds, primarily ethylbenzene and total xylenes, extended south from the Western Aquafarm, across a portion of LF-2 (including monitoring wells 39MW0002, 39MW0004, and 39MW0005) continuing to the southwest toward 39MW0006 and South Outer Road (Figure P-2). At that time, the Western Aquafarm plume was approximately 1,550 ft long, approximately 825 ft wide, and 40 to 60 ft thick (AFCEE 2008). As part of the MMR tank removal program, all USTs and associated piping at the Western Aquafarm were removed in 1994. Evidence of leakage associated with the piping and transfer support system was noted and approximately 450 cubic yards of contaminated soil were excavated and removed for thermal treatment. A long term monitoring (LTM) program of the Western Aquafarm groundwater plume was conducted through 2004, at which time a no further action determination was achieved since primary groundwater contaminants ethylbenzene and total xylenes were no longer detected at concentrations above the maximum contaminant levels (AFCEE 2006).

P1.3 SITE ASSESSMENT AND REMEDIATION CHRONOLOGY

A two-phase remedial investigation (RI) was completed at FTA-2 and LF-2 (ABB-ES 1996). The results of the RI indicated that the primary soil contaminants associated with the FTA-2 area were fuel-related volatile organic compounds (VOCs) and semivolatile organic compounds (SVOCs). Human health and ecological preliminary risk assessments were completed as part of the RI. No human health risks were identified but a risk to ecological receptors was identified. However, cleanup at FTA-2 was driven by potential impacts to groundwater due to the leaching of petroleum-related compounds from soil (AFCEE 2008).

A Record of Decision (ROD) was finalized in September 1998 (AFCEE 1998), which documented ethylbenzene and total xylenes as COCs for soil at FTA-2 because they were present in soil at concentrations high enough to pose a potential leaching threat to groundwater. In addition, site-specific soil target cleanup levels (STCLs) for ethylbenzene (700 micrograms per kilogram [µg/kg]) and total xylenes (10,000 µg/kg) were established. The selected remedy involved active remediation to decrease ethylbenzene and total xylenes concentrations in soils at FTA-2 to below STCLs.

A biosparging/vapor recovery (BSVR) system began operation within the approximate extent of FTA-2 (Figure P-1) in 2001 and was shut down in 2003 when remedial goals for soil were met (i.e., the STCLs for ethylbenzene and total xylenes in soil were achieved) (AFCEE 2003b). However, in order to obtain approval for a completed remedial action, the Massachusetts Department of Environmental Protection (MassDEP) required sampling of groundwater in the immediate vicinity of the biosparging/vapor recovery system and laboratory analysis for extractable petroleum hydrocarbons (EPH) and volatile petroleum hydrocarbons (VPH) using the MassDEP EPH/VPH Method. EPH/VPH concentrations greater than the Massachusetts Contingency Plan (MCP) Groundwater-1 (GW-1) cleanup standards were detected (AFCEE 2005a).

Additionally, in December 2004 as part of the Western Aquafarm groundwater monitoring program, 1,2,4-trimethylbenzene (1,2,4-TMB) and 1,3,5-trimethylbenzene (1,3,5-TMB) were detected in two monitoring wells (39MW0002 and 39MW0005A) located at FTA-2 (Figure P-2). In subsequent discussions with the U.S. Environmental Protection Agency (EPA) and MassDEP, it was determined that the TMB detections would be more appropriately addressed under the FTA-2 groundwater monitoring program (AFCEE 2008). Therefore, in 2004 a groundwater LTM program was established to monitor for TMBs and VOCs (specifically ethylbenzene and total xylenes) within the FTA-2 source area (AFCEE 2005b), while additional sampling was completed to better characterize the extent of groundwater contamination (including EPH/VPH) at the entire FTA-2 area.

Twelve groundwater sampling events at the FTA-2 area were completed between 2004 and 2010. Groundwater samples were typically analyzed for VOCs (including TMB isomers) and EPH/VPH, as well as occasionally for SVOCs, metals, and polychlorinated biphenyls. Summaries of these sampling events are documented in AFCEE 2008, 2009a, 2009b, and 2011.

P1.4 NEARBY BUILDINGS

There are no buildings within the FTA-2 area (Figure P-2). The nearest building is Building 9003, which is located approximately 600 ft southwest of the FTA-2 area. The next nearest building is Building 430, which is located approximately 680 ft west of the FTA-2 area. A hangar, Building 175, located approximately 880 ft southeast of the FTA-2 area, was demolished in 2011.

P1.5 NEARBY UTILITIES

Figure P-3 shows existing subsurface utilities in the vicinity of FTA-2. A pair of 72-inch-diameter reinforced concrete storm drains traverse FTA-2 in a northeast-southwest orientation. They originate at the SD-5 catchment basin north of the FTA-2 area and end at the SD-1 drainage ditch south of South Outer Road. Both ends of the

pipes were open to the atmosphere; however, the northern ends of both pipes were recently blocked off so they no longer receive surface water flow from the SD-5 catchment basin. The SD-5 catchment basin is no longer used.

Two 21-inch-diameter reinforced concrete pipes feed into the 72-inch-diameter drains from the east. This drainage system directs surface water runoff from the southern end of Runway No. 5 to the SD-1 Drainage Ditch. Thus, the southern ends of both 72-inch-diameter drains (at South Outer Road) are open to the atmosphere.

In addition, a 10-inch-diameter steel water line traverses the FTA-2 area along its northern boundary and then heads south near the FTA-2 area eastern boundary. Utilities south of the FTA-2 area include subsurface wastewater, water, and storm water pipelines.

Wells associated with the BSVR system that formerly operated at the FTA-2 remain within the footprint of the FTA-2. In addition, the associated BSVR system piping (Schedule 40 polyvinyl chloride [PVC] with backfill sand) remains at a depth of approximately 5 ft bgs within the footprint of the FTA-2 area. These BSVR utilities at the FTA-2 are not connected to any buildings and do not extend beyond the current footprint of the FTA-2.

P2.0 VAPOR INTRUSION SCREENING

The subsections that follow present the results of the VI screening evaluation using the most recent concentration data for groundwater and soil samples collected from numerous borings that have been advanced and monitoring wells that have been installed in the vicinity of the FTA-2 area.

P2.1 SOIL

Four field studies have been undertaken to define the nature and extent of landfill contents and soil contamination at FTA-2. An initial RI field program in 1989-1990 included advancing one soil boring, excavating four test pits, and submitting seven soil samples for laboratory analysis. This was followed by a second RI field program that was designed to define the limits of landfill in the FTA-2 area. The 1993 RI program included magnetometry and ground-penetrating radar geophysical surveys to evaluate the extent of landfilled material, test pitting at nine locations within the landfill to confirm geophysical results and characterize soils, advancement of three borings, and submission of 20 soil samples for laboratory analysis (ABB-ES 1996).

In 2002, four soil borings were advanced in the vicinity of the biosparging/vapor recovery treatment area at FTA-2 and 25 soil samples were submitted for VOC analysis to evaluate progress toward meeting remedial goals for FTA-2 soil established in the ROD. Results indicated that concentrations of ethylbenzene and xylenes were below STCLs in all samples. Based on those results, site closure confirmation samples were collected in January 2003. Six soil borings were advanced in the treatment area and 28 soil samples were submitted for VOC analysis. Samples from two borings were also submitted for VPH/EPH analysis. Results indicated that COC (ethylbenzene and xylenes) concentrations in soil were below STCLs and all other VOC and VPH concentrations in soil were below their respective MCP cleanup standards. Residual EPH concentrations in some samples were above the MCP Soil-1/Groundwater-1 (S-1/GW-1) standard for the C_{11}-C_{22} aromatic hydrocarbon fraction (AFCEE 2003b).

The most recent soil data (AFCEE 2003b) indicate that VI contaminants of potential concern (COPCs) are present at FTA-2. Furthermore, due to the history of landfilling at LF-2, the presence of VI COPCs in other portions of LF-2 also cannot be ruled out. Therefore, for the purposes of this VI evaluation, it is assumed that VI COPCs are likely to be present at detectable concentrations throughout LF-2 as delineated on Figure P-1. However, due to the efforts to delineate the landfill contents during the RI using multiple lines of evidence, COPCs originating from LF-2 are not anticipated to be present in soil outside of the delineated LF-2 boundaries. Accordingly, it is concluded that VI COPCs in soil associated with the FTA-2 area are not located within 100 ft of any buildings.

However, VI COPCs in the FTA-2 area soil are located within 100 ft of subsurface utilities, including storm drains and water lines. As mentioned previously, the 72-inch-diameter storm drains beneath FTA-2 are blocked at the northern ends and open to the atmosphere at the southern ends. Therefore, these drains would not serve as a preferential airflow pathway to buildings; vapor-phase contaminants from soil would tend to follow the path of least resistance and discharge to the atmosphere rather than continue traveling through air-filled spaces in soil. Similarly, the 21-inch-diameter storm drains beneath FTA-2 terminate at the 72-inch-diameter storm drains and at catch basins that are open to the atmosphere, and no buildings are located between these termini. Thus, the 21-inch-diameter storm drains would not serve as preferential airflow pathways to buildings either. Finally, the BSVR wells and piping that remain at FTA-2 are not connected to any buildings and therefore, are not considered to serve as preferential flow pathways to any buildings.

The 10-inch-diameter water lines do not terminate at the atmosphere and may be located within 100 ft of VI COPCs in soil (Figure P-3). However, the distance VI COPCs would need to travel before reaching a building is so great, at least 1,200 ft (to Building 322, for example), that VI impacts would be highly unlikely.

FTA-2 VI COPCs in soil thus do not pose a significant VI risk given current land uses nearby. Since the FTA-2 source area is located on the MMR, future development, including the construction of new buildings in this area, is controlled by base entities.

Specifically, the Air National Guard has administrative processes and procedures that require approval for all projects involving construction or digging/subsurface soil disturbance at the MMR. In the event construction activities were planned within the FTA-2 area, the Installation Restoration Program would take appropriate measures to address VI concerns as they relate to any future structures and/or underground utilities or other potential preferential airflow pathways.

P2.2 GROUNDWATER

Potential VI from contaminants in groundwater at FTA-2 was evaluated using the step-wise process described in Section 4.1 of the main document. A summary of the groundwater data used in this evaluation is provided in Table P-1. The comparison of VI COPC detections in the FTA-2 area to VI screening values is shown on Figure P-2, and well construction information is provided in Table P-2.

P2.1.1 Step 1: Clean Water Lens

The first step in evaluating the possibility of VI associated with groundwater contamination is determining whether and where a 3-ft thick clean water lens is constantly present above the contamination and is expected to remain for the foreseeable future as long as the contamination exists. If the evaluation indicates that a clean water lens is present using the criteria presented in Section 4.1.1 of the main document, it can be concluded that the groundwater-to-indoor-air VI pathway is incomplete and no further evaluation related to groundwater is required.

Monitoring wells installed at the FTA-2 area and used in this VI evaluation are screened at or near the water table. As shown in Table P-1, fuel-related VOCs were detected in samples from many of the monitoring wells; in addition, several chlorinated VOCs (i.e., trichloroethene, tetrachloroethene, and carbon tetrachloride) were detected at some locations. Therefore, a clean water lens is not present at the FTA-2 area and a complete VI pathway cannot be ruled out; further VI evaluation (i.e., Step 2 of the groundwater VI evaluation process) is warranted.

P2.1.2 Step 2: Buildings and Preferential Airflow Pathways

As shown on Figure P-2, there are no detections of VI COPCs within 100 ft of buildings. However, the monitoring well network is insufficient to establish the extent of groundwater detections west of well 05MW0002. Therefore, VI COPC detections within 100 ft of Building 430 cannot be ruled out on the basis of existing information.

VI COPCs have been detected within 100 ft of potential preferential airflow pathways, i.e., at 39DP0103 adjacent to the water line beneath South Outer Road, as well as at 28MW0106 and 28MW0005 adjacent to the water line beneath Lingley Avenue (Figures P-2 and P-3). Thus, further VI evaluation (i.e., Step 3 of the groundwater VI evaluation process) is needed.

P2.1.3 Step 3: Compare Groundwater Concentrations to VI Screening Values

Table P-1 compares the latest available VI COPC concentrations detected in groundwater (sampled over a date range from 1999 to 2011) to the groundwater-to-indoor-air screening values specified in Table 4-1 of the main document. Locations that exceed a screening value for one or more of the VI COPCs are indicated on Figure P-3. Although some of these groundwater analytical data were collected over 10 years ago, the more recent data collected in 2011 indicate that groundwater contamination remains at the water table interface in the FTA-2 area.

Screening values are exceeded at one or more wells for the following VI COPCs: 1,2,4-TMB, 1,3,5-TMB, C_5-C_8 aliphatic hydrocarbons, C_9-C_{12} aliphatic hydrocarbons, naphthalene, and 2-methylnaphthalene. There are 10 wells with screening value exceedances within the FTA-2 area. None of the wells with VI COPC screening level exceedances are located within 100 ft of a building.

Three wells with exceedances of screening values are within 100 ft of potential preferential airflow pathways, i.e., subsurface storm drains and water lines. Well 39MW0002 is within 100 ft of the 72-inch-diameter storm drain. However, this drain does not serve as a preferential airflow pathway to buildings (Section P2.1). The other

two wells, 28MW0005 and 28MW0106, are within 100 ft of the 10-inch-diameter water line beneath Lingley Avenue. The VI COPCs exceeding screening values at these two wells are 1,2,4-TMB and 1,3,5-TMB.

Despite the proximity of wells 28MW0005 and 28MW0106 to the water line, VI impacts to an occupied building due to these screening value exceedances would be unlikely for a number of reasons:

1) The depth to groundwater is 45 to 50 ft, thus vapors would need to travel upward a considerable distance before reaching the water line.
2) TMBs would be expected to biodegrade as they traveled upward in the vadose zone and encountered oxygen and the appropriate microbial consortia (Delhomenie et al. 2003, Hutchins 1991).
3) If the vapors reached the water distribution line, they would then need to travel at least 1,200 ft before reaching the nearest permanent building (322) that is serviced by this utility.
4) Buildings PB318E, PB318F, PB510, and PB537 are construction trailers. Thus, an air space is present between the building floor and the ground surface and the likelihood of vapors travelling along the preferential airflow pathway entering the building would be remote.
5) TMB concentrations do not exceed the screening values by one or more orders of magnitude. The screening value for both 1,2,4-TMB and 1,3,5-TMB is 7.8 micrograms per liter (µg/L), while the highest detected concentration was 42 µg/L.

Part of the comparison to screening values in Step 3 includes evaluating whether VI COPC concentrations in groundwater are increasing, stable, or decreasing. Groundwater in the vicinity of FTA-2 (i.e., in the field of view shown on Figure P-2) is monitored under FTA-2 and SD-5 LTM programs. LTM data indicate that groundwater concentrations in the FTA-2 and SD-5 areas are either stable or decreasing (AFCEE 2012, 2010).

Another component of Step 3 is to determine whether contaminant sources have been adequately controlled. The success of biosparging/vapor recovery in addressing contaminant sources at FTA-2 has been documented (AFCEE 2003b), and tanks and piping, as well as contaminated soil, at the Western Aquafarm have also been removed (AFCEE 2008). Decreasing concentrations in the SD-5 plume (AFCEE 2010) similarly attest to the adequacy of controlling the sources of the SD-5 plume. Thus, available information indicates that contaminant sources in the vicinity of FTA-2 have been adequately controlled.

The final component of Step 3 is to evaluate whether characterization data are adequate. It has been possible to draw conclusions relative to VI potential associated with FTA-2 based on the available historical information as well as soil and groundwater data, as explained above. Thus, characterization data are considered adequate for the purposes of assessing VI potential relative to the FTA-2 area.

P3.0 CONCLUSIONS AND RECOMMENDATIONS

P3.1 CONCLUSIONS

VI COPCs in soil are not located within 100 ft of any buildings. VI COPCs in soil are located within 100 ft of subsurface utilities that could act as preferential airflow pathways; however, associated VI impacts are unlikely due to the relatively long travel distances between the soil VI COPCs and nearest buildings (over 1,000 ft).

A clean water lens is not present at FTA-2. VI COPCs in groundwater have not been detected within 100 ft of any buildings; however, the monitoring network is insufficient to definitively rule out the presence of VI COPCs in groundwater within 100 ft of nearby buildings. In addition, VI COPCs in groundwater are located within 100 ft of subsurface utilities. These findings necessitated further evaluation.

VI COPC concentrations exceed groundwater-to-indoor-air screening values at 10 wells. Three of these 10 wells are located within 100 ft of subsurface utilities. However, VI impacts from the FTA-2 area groundwater are unlikely due to the nature of the utilities and the nearby buildings, relatively long travel distances involved, relatively small magnitudes of the screening level exceedances, and generally decreasing VI COPC concentrations in groundwater.

P3.2 RECOMMENDATIONS

No further monitoring or data collection is needed specific to VI. However, as part of the ongoing LTM program at FTA-2, AFCEE will continue to monitor the extent and attenuation of the VI COPCs. The VI exposure pathway will be re-evaluated if conditions change such that VI could become a concern.

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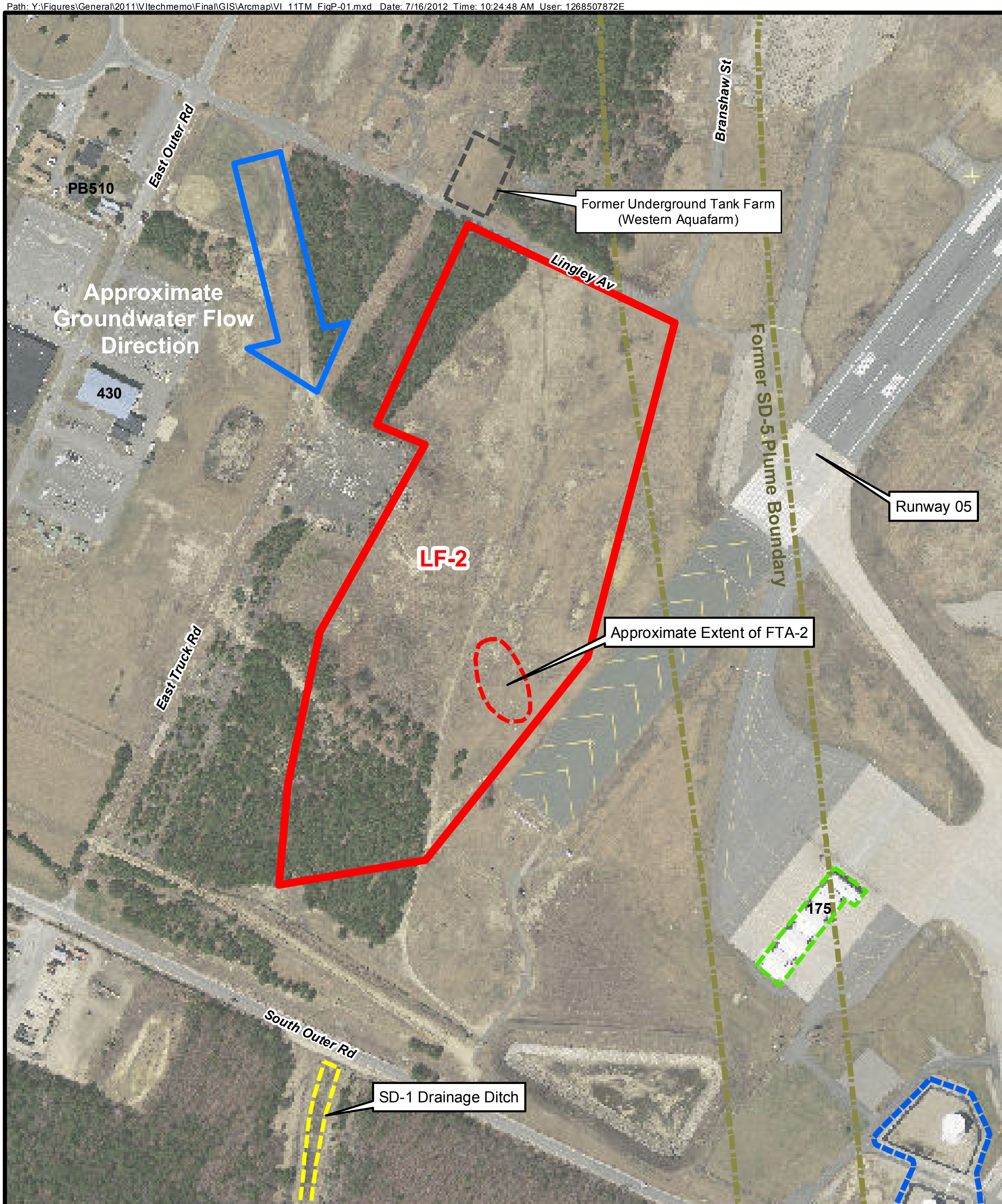

Legend

	FTA-2 Source Area	175	Building Number
	Historic Tank Farm	SD	Storm Drain
	LF-2 Boundary		Historic Plume Boundary
	PFSA Structures Demolished 2011		Building 175 Demolished 2011

Data Source: AFCEE, MMR-AFCEE Data Warehouse
2009 Aerial Photography from MassGIS

N

0 190 380 Feet

FIGURE P-1

FTA-2 AREA

AFCEE - Massachusetts Military Reservation

Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

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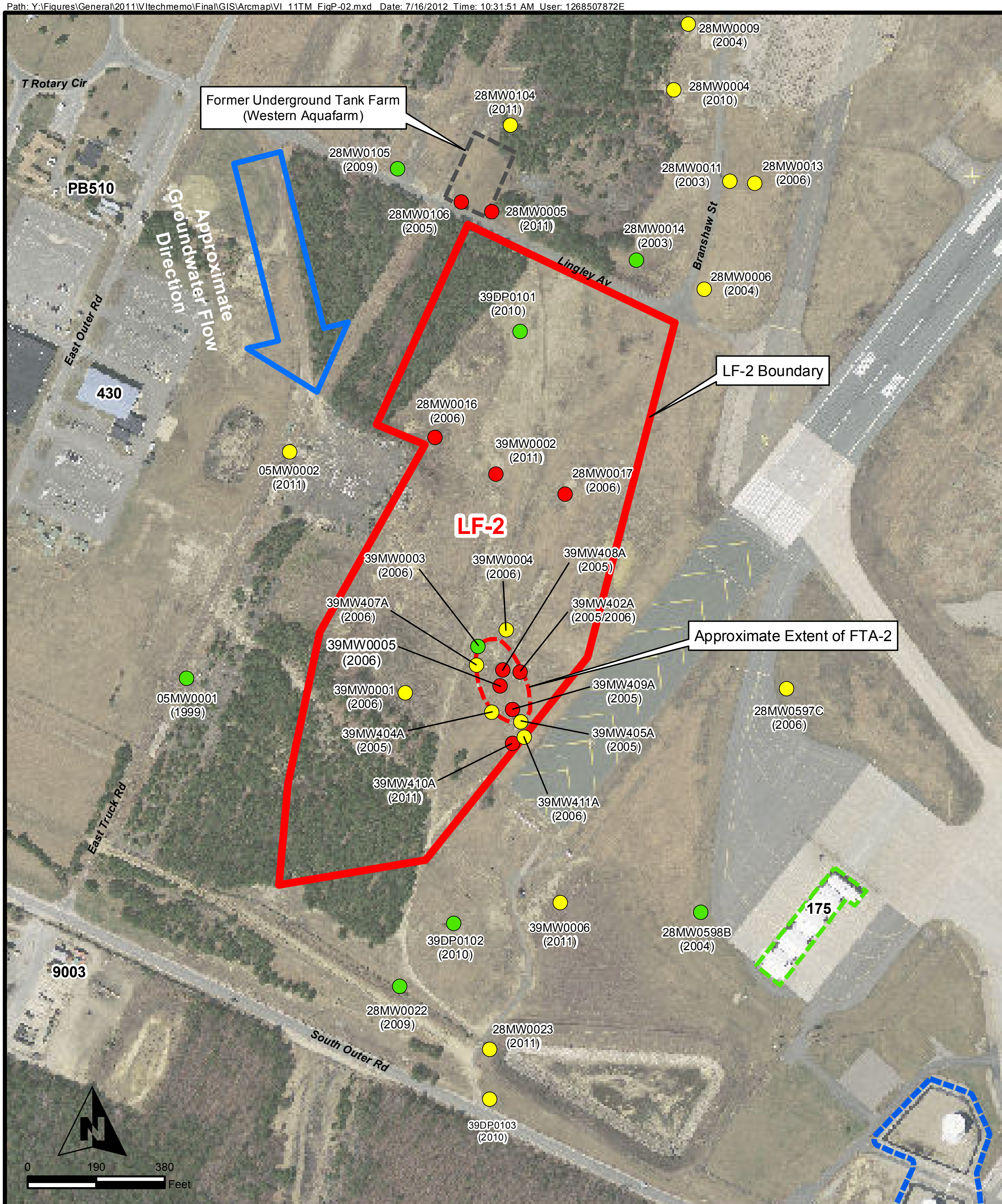

Legend

Building 175 Demolished 2011

PFSA Structures Demolished 2011

Locations with an Exceedance of a VI COPC Screening Value*

Locations With VI COPC Detection Below Its Screening Values*

Locations With No VI COPC Detections*

(2010) (2010) (2009)

Data Source: AFCEE, MMR-AFCEE Data Warehouse
2009 Aerial Photography from MassGIS

175 Building Number

Notes:

*Date refers to the most recent date of sample collection

VI COPC (vapor intrusion contaminant of potential concern).

Groundwater samples were collected at or near the water table. Refer to Table 4-1 of main document for a list of VI COPCs and associated groundwater to indoor air screening values.

FIGURE P-2

FTA-2 AREA GROUNDWATER DATA SUMMARY

AFCEE - Massachusetts Military Reservation

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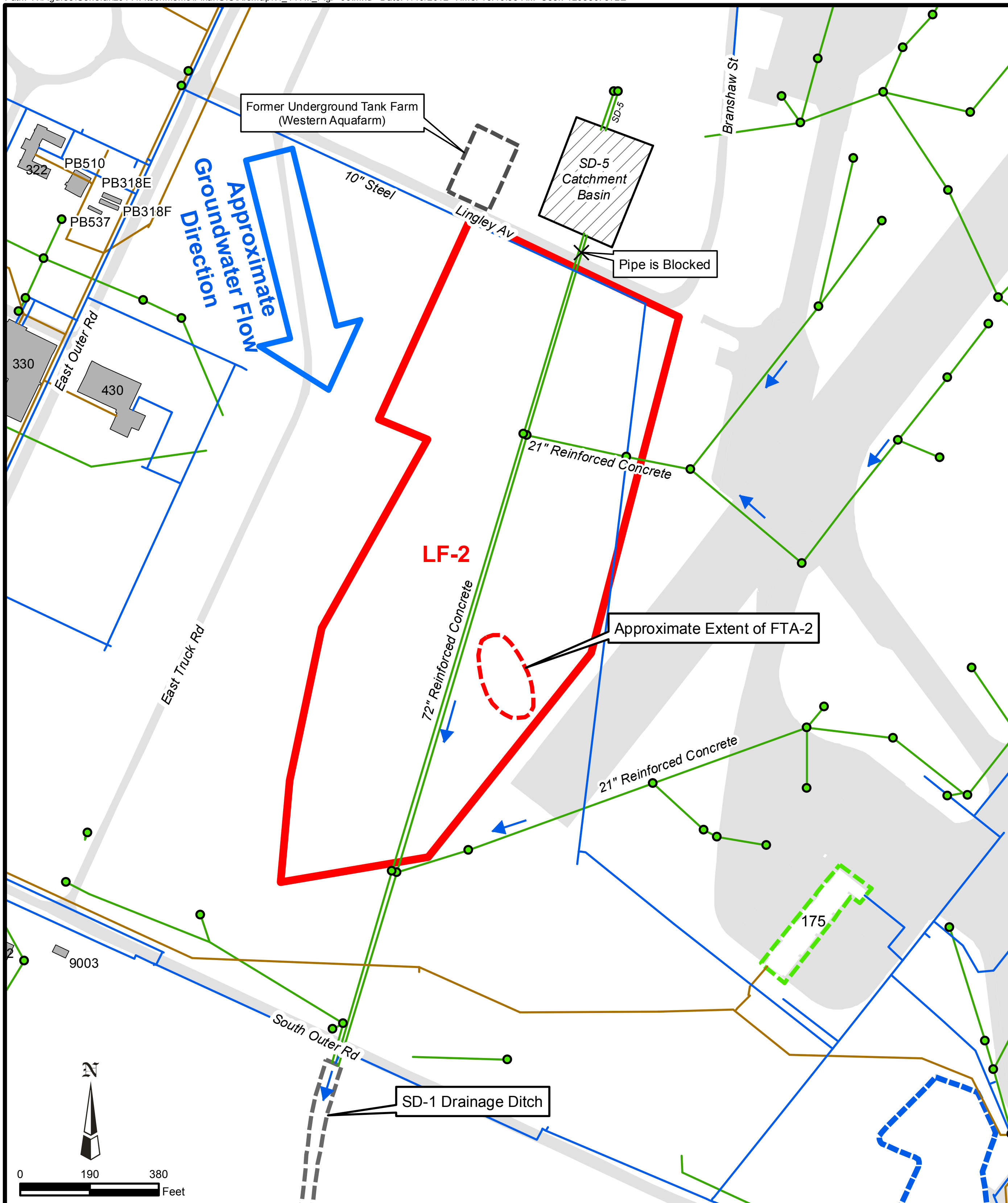

Legend

LF-2 Boundary	Wastewater Pipe	Existing Building
FTA-2 Source Area	Water Supply Pipe	Pavement/Surface Road
Historic Tank Farm	Storm Water Pipe	Direction of Flow
Storm Water Inlet Point	Building 175 Demolished 2011	175 Building Number
	PFSA Structures Demolished 2011	SD Storm Drain

Data Source: AFCEE, MMR-AFCEE Data Warehouse
January 2012 GIS data from Massachusetts Air National Guard

FIGURE P-3

FTA-2 AREA EXISTING SUBSURFACE UTILITIES

AFCEE - Massachusetts Military Reservation

Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

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Table P-1
Comparison of Detected Concentrations in FTA-2 Area Groundwater
to Applicable Groundwater-to-Indoor Air Screening Values
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Location	Date	Mid-screen elevation (ft msl)	Sampling Method[1]	VI COPC[1]	Result	DL	RL	MCP Method 1 GW-2 Standard[2] (µg/L)	VI Screening Value Exceeded?	Generic Unrestricted Groundwater Screening Value[3] (µg/L)	VI Screening Value Exceeded?
					All units = µg/L						
05MW0001*	2/4/1999	47.59	MW	No VI COPCs detected	ND	--	--	--	--	--	--
05MW0002	12/21/2011	45.00	MW	C5-C8 ALIPHATIC HYDROCARBONS	BRL	10	20	3,000	No	NE	NA
28MW0004*	8/6/2010	49.76	MW	TETRACHLOROETHENE (PCE)	1	0.19	1	50	No	13	No
28MW0004*	8/6/2010	49.76	MW	TRICHLOROETHENE (TCE)	3	0.2	1	30	No	5	No
28MW0005	12/20/2011	44.82	MW	1,2,4-TRIMETHYLBENZENE	**32**	0.22	1	NE	NA	7.8	Yes
28MW0005	12/20/2011	44.82	MW	1,3,5-TRIMETHYLBENZENE (MESITYLENE)	**42**	0.2	1	NE	NA	7.8	Yes
28MW0005	12/20/2011	44.82	MW	2-METHYLNAPHTHALENE	8	0.1	0.2	2,000	No	12	No
28MW0005	12/20/2011	44.82	MW	C5-C8 ALIPHATIC HYDROCARBONS	1,430 J	50	100	3,000	No	NE	NA
28MW0005	12/20/2011	44.82	MW	C9-C10 AROMATIC HYDROCARBONS	694 J	50	100	7,000	No	NE	NA
28MW0005	12/20/2011	44.82	MW	C9-C12 ALIPHATIC HYDROCARBONS	701 J	50	100	5,000	No	NE	NA
28MW0005	12/20/2011	44.82	MW	C9-C18 ALIPHATIC HYDROCARBONS	BRL	100	200	5,000	No	NE	NA
28MW0005	12/20/2011	44.82	MW	TOLUENE	BRL	0.2	1	50,000	No	4,100	No
28MW0006*	9/30/2004	47.45	MW	TETRACHLOROETHENE (PCE)	BRL	0.18	1	50	No	13	No
28MW0006*	9/30/2004	47.45	MW	TRICHLOROETHENE (TCE)	2	0.11	1	30	No	5	No
28MW0009*	9/30/2004	48.39	MW	TETRACHLOROETHENE (PCE)	BRL	0.18	1	50	No	13	No
28MW0011*	3/4/2003	47.90	MW	TETRACHLOROETHENE (PCE)	BRL	0.146	1	50	No	13	No
28MW0011*	3/4/2003	47.90	MW	TRICHLOROETHENE (TCE)	5	0.138	1	30	No	5	No
28MW0013*	8/9/2006	49.07	MW	TETRACHLOROETHENE (PCE)	3	0.15	1	50	No	13	No
28MW0013*	8/9/2006	49.07	MW	TRICHLOROETHENE (TCE)	BRL	0.15	1	30	No	5	No
28MW0014*	6/24/2003	47.08	MW	No VI COPCs detected	ND	--	--	--	--	--	--
28MW0016	11/1/2006	46.79	MW	1,2,4-TRIMETHYLBENZENE	**880**	0.9	10	NE	NA	7.8	Yes
28MW0016	11/1/2006	46.79	MW	1,3,5-TRIMETHYLBENZENE (MESITYLENE)	**480**	0.7	10	NE	NA	7.8	Yes
28MW0016	11/1/2006	46.79	MW	C5-C8 ALIPHATIC HYDROCARBONS	**3,600**	100	100	3,000	Yes	NE	NA
28MW0016	11/1/2006	46.79	MW	C9-C10 AROMATIC HYDROCARBONS	3,000	100	100	7,000	No	NE	NA
28MW0016	11/1/2006	46.79	MW	C9-C12 ALIPHATIC HYDROCARBONS	570	100	100	5,000	No	NE	NA
28MW0016	11/1/2006	46.79	MW	ETHYLBENZENE	BRL	0.6	5	20,000	No	700	No
28MW0016	11/1/2006	46.79	MW	M,P-XYLENE (SUM OF ISOMERS)	BRL	0.95	10	9,000	No	10,000	No
28MW0016	11/1/2006	46.79	MW	TOLUENE	BRL	0.55	5	50,000	No	4,100	No
28MW0017	11/1/2006	46.38	MW	1,2,4-TRIMETHYLBENZENE	**223**	0.45	5	NE	NA	7.8	Yes
28MW0017	11/1/2006	46.38	MW	1,3,5-TRIMETHYLBENZENE (MESITYLENE)	**124**	0.14	2	NE	NA	7.8	Yes
28MW0017	11/1/2006	46.38	MW	2-METHYLNAPHTHALENE	2	0.5	0.5	2,000	No	12	No
28MW0017	11/1/2006	46.38	MW	C5-C8 ALIPHATIC HYDROCARBONS	2,000	40	40	3,000	No	NE	NA
28MW0017	11/1/2006	46.38	MW	C9-C10 AROMATIC HYDROCARBONS	830	40	40	7,000	No	NE	NA
28MW0017	11/1/2006	46.38	MW	C9-C12 ALIPHATIC HYDROCARBONS	290	40	40	5,000	No	NE	NA
28MW0017	11/1/2006	46.38	MW	ETHYLBENZENE	88	10	10	20,000	No	700	No
28MW0017	11/1/2006	46.38	MW	M,P-XYLENE (SUM OF ISOMERS)	340	10	10	9,000	No	10,000	No
28MW0017	11/1/2006	46.38	MW	NAPHTHALENE	**20**	10	10	1,000	No	12	Yes
28MW0017	11/1/2006	46.38	MW	O-XYLENE (1,2-DIMETHYLBENZENE)	110	10	10	9,000	No	10,000	No
28MW0022	3/30/2009	37.29	MW	No VI COPCs detected	ND	--	--	--	--	--	--
28MW0023	12/21/2011	35.78	MW	C5-C8 ALIPHATIC HYDROCARBONS	264	10	20	3,000	No	NE	NA
28MW0104	12/20/2011	46.03	MW	C5-C8 ALIPHATIC HYDROCARBONS	BRL	10	20	3,000	No	NE	NA
28MW0105	3/31/2009	48.64	MW	No VI COPCs detected	ND	--	--	--	--	--	--
28MW0106*	12/30/2005	48.21	MW	1,2,4-TRIMETHYLBENZENE	**9**	0.55	5	NE	NA	7.8	Yes
28MW0106*	12/30/2005	48.21	MW	1,3,5-TRIMETHYLBENZENE (MESITYLENE)	**13**	0.85	5	NE	NA	7.8	Yes
28MW0597C*	8/31/2006	43.64	MW	TETRACHLOROETHENE (PCE)	BRL	0.15	1	50	No	13	No
28MW0598B*	10/6/2004	45.16	MW	No VI COPCs detected	ND	--	--	--	--	--	--
39DP0101	6/7/2010	55.50	MW	No VI COPCs detected	ND	--	--	--	--	--	--
39DP0102	6/11/2010	51.50	MW	No VI COPCs detected	ND	--	--	--	--	--	--
39DP0103	6/8/2010	49.50	MW	NAPHTHALENE	BRL	0.134	0.4	1,000	No	12	No
39MW0001	11/2/2006	46.80	MW	CARBON TETRACHLORIDE	BRL	0.15	1	2	No	5	No
39MW0002	12/21/2011	40.07	MW	1,2,4-TRIMETHYLBENZENE	**1,120**	4.4	20	NE	NA	7.8	Yes
39MW0002	12/21/2011	40.07	MW	1,3,5-TRIMETHYLBENZENE (MESITYLENE)	**494**	4	20	NE	NA	7.8	Yes
39MW0002	12/21/2011	40.07	MW	2-METHYLNAPHTHALENE	**28**	2	4	2,000	No	12	Yes
39MW0002	12/21/2011	40.07	MW	C5-C8 ALIPHATIC HYDROCARBONS	**4,580 J**	200	400	3,000	Yes	NE	NA
39MW0002	12/21/2011	40.07	MW	C9-C10 AROMATIC HYDROCARBONS	4,140	200	400	7,000	No	NE	NA
39MW0002	12/21/2011	40.07	MW	C9-C12 ALIPHATIC HYDROCARBONS	**5,670**	200	400	5,000	Yes	NE	NA
39MW0002	12/21/2011	40.07	MW	C9-C18 ALIPHATIC HYDROCARBONS	235	100	200	5,000	No	NE	NA
39MW0002	12/21/2011	40.07	MW	ETHYLBENZENE	559	4	20	20,000	No	700	No
39MW0002	12/21/2011	40.07	MW	M,P-XYLENE (SUM OF ISOMERS)	2,270	8	20	9,000	No	10,000	No
39MW0002	12/21/2011	40.07	MW	NAPHTHALENE	**125**	2	4	1,000	No	12	Yes
39MW0002	12/21/2011	40.07	MW	O-XYLENE (1,2-DIMETHYLBENZENE)	688	4	20	9,000	No	10,000	No
39MW0002	12/21/2011	40.07	MW	TETRACHLOROETHENE (PCE)	BRL	0.19	1	50	No	13	No
39MW0002	12/21/2011	40.07	MW	TOLUENE	6	0.2	1	50,000	No	4,100	No
39MW0002	12/21/2011	40.07	MW	TRICHLOROETHENE (TCE)	BRL	0.2	1	30	No	5	No
39MW0003	11/1/2006	44.60	MW	No VI COPCs detected	ND	--	--	--	--	--	--
39MW0004	11/1/2006	50.20	MW	TRICHLOROETHENE (TCE)	BRL	0.15	1	30	No	5	No

Table P-1
Comparison of Detected Concentrations in FTA-2 Area Groundwater
to Applicable Groundwater-to-Indoor Air Screening Values
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Location	Date	Mid-screen elevation (ft msl)	Sampling Method[1]	VI COPC[1]	Result	DL	RL	MCP Method 1 GW-2 Standard[2] (µg/L)	VI Screening Value Exceeded?	Generic Unrestricted Groundwater Screening Value[3] (µg/L)	VI Screening Value Exceeded?
					All units = µg/L						
39MW0005	11/2/2006	48.12	MW	1,2,4-TRIMETHYLBENZENE	**10**	0.09	1	NE	NA	7.8	Yes
39MW0005	11/2/2006	48.12	MW	2-METHYLNAPHTHALENE	**17**	0.56	0.56	2,000	No	12	Yes
39MW0005	11/2/2006	48.12	MW	C11-C22 AROMATIC HYDROCARBONS	470	170	170	50,000	No	NE	NA
39MW0005	11/2/2006	48.12	MW	C5-C8 ALIPHATIC HYDROCARBONS	50	20	20	3,000	No	NE	NA
39MW0005	11/2/2006	48.12	MW	C9-C10 AROMATIC HYDROCARBONS	480	20	20	7,000	No	NE	NA
39MW0005	11/2/2006	48.12	MW	C9-C12 ALIPHATIC HYDROCARBONS	180	20	20	5,000	No	NE	NA
39MW0005	11/2/2006	48.12	MW	cis-1,2-DICHLOROETHENE	3	0.2	1	100	No	70	No
39MW0005	11/2/2006	48.12	MW	ETHYLBENZENE	BRL	0.12	1	20,000	No	700	No
39MW0005	11/2/2006	48.12	MW	M,P-XYLENE (SUM OF ISOMERS)	BRL	0.19	2	9,000	No	10,000	No
39MW0005	11/2/2006	48.12	MW	NAPHTHALENE	**41**	5	5	1,000	No	12	Yes
39MW0005	11/2/2006	48.12	MW	TOLUENE	BRL	0.11	1	50,000	No	4,100	No
39MW0005	11/2/2006	48.12	MW	TRICHLOROETHENE (TCE)	BRL	0.15	1	30	No	5	No
39MW0006	12/20/2011	45.77	MW	C5-C8 ALIPHATIC HYDROCARBONS	BRL	10	20	3,000	No	NE	NA
39MW0006	12/20/2011	45.77	MW	C9-C12 ALIPHATIC HYDROCARBONS	BRL	10	20	5,000	No	NE	NA
39MW402A	10/26/2005	45.91	MW	1,2,4-TRIMETHYLBENZENE	**200**	1.25	6.3	NE	NA	7.8	Yes
39MW402A	10/26/2005	45.91	MW	1,3,5-TRIMETHYLBENZENE (MESITYLENE)	**140**	1.625	6.3	NE	NA	7.8	Yes
39MW402A	11/2/2006	45.91	MW	1,4-DICHLOROBENZENE	BRL	0.11	1	200	No	75	No
39MW402A	11/2/2006	45.91	MW	C11-C22 AROMATIC HYDROCARBONS	260	150	150	50,000	No	NE	NA
39MW402A	11/2/2006	45.91	MW	C9-C10 AROMATIC HYDROCARBONS	120	20	20	7,000	No	NE	NA
39MW402A	11/2/2006	45.91	MW	C9-C12 ALIPHATIC HYDROCARBONS	32	20	20	5,000	No	NE	NA
39MW402A	11/2/2006	45.91	MW	cis-1,2-DICHLOROETHENE	BRL	0.2	1	100	No	70	No
39MW402A	11/2/2006	45.91	MW	O-XYLENE (1,2-DIMETHYLBENZENE)	BRL	0.1	1	9,000	No	10,000	No
39MW402A	11/2/2006	45.91	MW	TRICHLOROETHENE (TCE)	BRL	0.15	1	30	No	5	No
39MW404A	10/26/2005	50.52	MW	1,2,4-TRIMETHYLBENZENE	BRL	0.1	0.5	NE	NA	7.8	No
39MW404A	10/26/2005	50.52	MW	1,3,5-TRIMETHYLBENZENE (MESITYLENE)	BRL	0.13	0.5	NE	NA	7.8	No
39MW404A	10/26/2005	50.52	MW	C11-C22 AROMATIC HYDROCARBONS	130	100	100	50,000	No	NE	NA
39MW404A	10/26/2005	50.52	MW	C5-C8 ALIPHATIC HYDROCARBONS	47	10	10	3,000	No	NE	NA
39MW404A	10/26/2005	50.52	MW	C9-C10 AROMATIC HYDROCARBONS	150	10	10	7,000	No	NE	NA
39MW404A	10/26/2005	50.52	MW	C9-C12 ALIPHATIC HYDROCARBONS	147	10	10	5,000	No	NE	NA
39MW404A	10/26/2005	50.52	MW	C9-C18 ALIPHATIC HYDROCARBONS	BRL	36	100	5,000	No	NE	NA
39MW404A	10/26/2005	50.52	MW	cis-1,2-DICHLOROETHENE	1	0.15	0.5	100	No	70	No
39MW404A	10/26/2005	50.52	MW	ETHYLBENZENE	BRL	0.1	0.5	20,000	No	700	No
39MW404A	10/26/2005	50.52	MW	TRICHLOROETHENE (TCE)	BRL	0.1	0.5	30	No	5	No
39MW405A	10/27/2005	45.72	MW	C11-C22 AROMATIC HYDROCARBONS	134	100	100	50,000	No	NE	NA
39MW405A	10/27/2005	45.72	MW	C9-C12 ALIPHATIC HYDROCARBONS	128	10	10	5,000	No	NE	NA
39MW405A	10/27/2005	45.72	MW	cis-1,2-DICHLOROETHENE	BRL	0.15	0.5	100	No	70	No
39MW405A	10/27/2005	45.72	MW	TRICHLOROETHENE (TCE)	BRL	0.1	0.5	30	No	5	No
39MW407A	11/2/2006	39.35	MW	1,2,4-TRIMETHYLBENZENE	2	0.09	1	NE	NA	7.8	No
39MW407A	11/2/2006	39.35	MW	1,3,5-TRIMETHYLBENZENE (MESITYLENE)	BRL	0.07	1	NE	NA	7.8	No
39MW407A	11/2/2006	39.35	MW	ETHYLBENZENE	BRL	0.12	1	20,000	No	700	No
39MW407A	11/2/2006	39.35	MW	M,P-XYLENE (SUM OF ISOMERS)	3	0.19	2	9,000	No	10,000	No
39MW407A	11/2/2006	39.35	MW	O-XYLENE (1,2-DIMETHYLBENZENE)	BRL	0.1	1	9,000	No	10,000	No
39MW408A	10/26/2005	44.64	MW	1,2,4-TRIMETHYLBENZENE	**28**	0.5	2.5	NE	NA	7.8	Yes
39MW408A	10/26/2005	44.64	MW	1,3,5-TRIMETHYLBENZENE (MESITYLENE)	**42**	0.65	2.5	NE	NA	7.8	Yes
39MW408A	10/26/2005	44.64	MW	2-METHYLNAPHTHALENE	11	5	5	2,000	No	12	No
39MW408A	10/26/2005	44.64	MW	C11-C22 AROMATIC HYDROCARBONS	BRL	74	100	50,000	No	NE	NA
39MW408A	10/26/2005	44.64	MW	C5-C8 ALIPHATIC HYDROCARBONS	1,230	10	10	3,000	No	NE	NA
39MW408A	10/26/2005	44.64	MW	C9-C10 AROMATIC HYDROCARBONS	433	10	10	7,000	No	NE	NA
39MW408A	10/26/2005	44.64	MW	C9-C12 ALIPHATIC HYDROCARBONS	569	10	10	5,000	No	NE	NA
39MW408A	10/26/2005	44.64	MW	C9-C18 ALIPHATIC HYDROCARBONS	219	100	100	5,000	No	NE	NA
39MW408A	10/26/2005	44.64	MW	ETHYLBENZENE	103	1	1	20,000	No	700	No
39MW408A	10/26/2005	44.64	MW	M,P-XYLENE (SUM OF ISOMERS)	42	1	1	9,000	No	10,000	No
39MW408A	10/26/2005	44.64	MW	NAPHTHALENE	**29**	1	1	1,000	No	12	Yes
39MW408A	10/26/2005	44.64	MW	TOLUENE	1	1	1	50,000	No	4,100	No
39MW409A	10/26/2005	48.23	MW	1,2,4-TRIMETHYLBENZENE	**36**	0.2	1	NE	NA	7.8	Yes
39MW409A	10/26/2005	48.23	MW	1,3,5-TRIMETHYLBENZENE (MESITYLENE)	**20**	0.13	0.5	NE	NA	7.8	Yes
39MW409A	10/26/2005	48.23	MW	2-METHYLNAPHTHALENE	**23**	5	5	2,000	No	12	Yes
39MW409A	10/26/2005	48.23	MW	C11-C22 AROMATIC HYDROCARBONS	164	100	100	50,000	No	NE	NA
39MW409A	10/26/2005	48.23	MW	C5-C8 ALIPHATIC HYDROCARBONS	304	10	10	3,000	No	NE	NA
39MW409A	10/26/2005	48.23	MW	C9-C10 AROMATIC HYDROCARBONS	377	10	10	7,000	No	NE	NA
39MW409A	10/26/2005	48.23	MW	C9-C12 ALIPHATIC HYDROCARBONS	328	10	10	5,000	No	NE	NA
39MW409A	10/26/2005	48.23	MW	C9-C18 ALIPHATIC HYDROCARBONS	BRL	98	100	5,000	No	NE	NA
39MW409A	10/26/2005	48.23	MW	ETHYLBENZENE	2	0.1	0.5	20,000	No	700	No
39MW409A	10/26/2005	48.23	MW	M,P-XYLENE (SUM OF ISOMERS)	BRL	0.2	1	9,000	No	10,000	No
39MW409A	10/26/2005	48.23	MW	NAPHTHALENE	8	1	1	1,000	No	12	No
39MW409A	10/26/2005	48.23	MW	TRICHLOROETHENE (TCE)	BRL	0.1	0.5	30	No	5	No

Table P-1
Comparison of Detected Concentrations in FTA-2 Area Groundwater
to Applicable Groundwater-to-Indoor Air Screening Values
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Location	Date	Mid-screen elevation (ft msl)	Sampling Method[1]	VI COPC[1]	Result	DL	RL	MCP Method 1 GW-2 Standard[2] (µg/L)	VI Screening Value Exceeded?	Generic Unrestricted Groundwater Screening Value[3] (µg/L)	VI Screening Value Exceeded?
					All units = µg/L						
39MW409A	10/26/2005	48.23	MW	XYLENES, TOTAL	1	0.1	0.5	9,000	No	10,000	No
39MW410A	12/20/2011	47.28	MW	1,2,4-TRIMETHYLBENZENE	**24**	0.22	1	NE	NA	7.8	Yes
39MW410A	12/20/2011	47.28	MW	1,3,5-TRIMETHYLBENZENE (MESITYLENE)	**13**	0.2	1	NE	NA	7.8	Yes
39MW410A	12/20/2011	47.28	MW	2-METHYLNAPHTHALENE	4	0.1	0.2	2,000	No	12	No
39MW410A	12/20/2011	47.28	MW	C11-C22 AROMATIC HYDROCARBONS	262	75	150	50,000	No	NE	NA
39MW410A	12/20/2011	47.28	MW	C5-C8 ALIPHATIC HYDROCARBONS	104	10	20	3,000	No	NE	NA
39MW410A	12/20/2011	47.28	MW	C9-C10 AROMATIC HYDROCARBONS	350	10	20	7,000	No	NE	NA
39MW410A	12/20/2011	47.28	MW	C9-C12 ALIPHATIC HYDROCARBONS	379	10	20	5,000	No	NE	NA
39MW410A	12/20/2011	47.28	MW	C9-C18 ALIPHATIC HYDROCARBONS	BRL	100	200	5,000	No	NE	NA
39MW410A	12/20/2011	47.28	MW	cis-1,2-DICHLOROETHENE	1	0.2	1	100	No	70	No
39MW410A	12/20/2011	47.28	MW	ETHYLBENZENE	1	1	1	20,000	No	700	No
39MW410A	12/20/2011	47.28	MW	M,P-XYLENE (SUM OF ISOMERS)	BRL	0.4	1	9,000	No	10,000	No
39MW410A	12/20/2011	47.28	MW	NAPHTHALENE	9	0.1	0.2	1,000	No	12	No
39MW410A	12/20/2011	47.28	MW	TRICHLOROETHENE (TCE)	BRL	0.2	1	30	No	5	No
39MW411A	11/2/2006	44.87	MW	1,2,4-TRIMETHYLBENZENE	BRL	0.09	1	NE	NA	7.8	No
39MW411A	11/2/2006	44.87	MW	C11-C22 AROMATIC HYDROCARBONS	170	170	170	50,000	No	NE	NA
39MW411A	11/2/2006	44.87	MW	C5-C8 ALIPHATIC HYDROCARBONS	24	20	20	3,000	No	NE	NA
39MW411A	11/2/2006	44.87	MW	C9-C10 AROMATIC HYDROCARBONS	73	20	20	7,000	No	NE	NA
39MW411A	11/2/2006	44.87	MW	C9-C12 ALIPHATIC HYDROCARBONS	32	20	20	5,000	No	NE	NA
39MW411A	11/2/2006	44.87	MW	cis-1,2-DICHLOROETHENE	BRL	0.2	1	100	No	70	No
39MW411A	11/2/2006	44.87	MW	ETHYLBENZENE	2	0.12	1	20,000	No	700	No
39MW411A	11/2/2006	44.87	MW	O-XYLENE (1,2-DIMETHYLBENZENE)	BRL	0.1	1	9,000	No	10,000	No
39MW411A	11/2/2006	44.87	MW	TRICHLOROETHENE (TCE)	BRL	0.15	1	30	No	5	No

Data Source: AFCEE, June 2012, MMR-AFCEE Data Warehouse

Notes:

1. All locations sampled for VOC s by EPA Method 8260B and EPH/VPH by MassDEP Method unless otherwise noted.

2. 310 CMR 40.0974(2) http://www.mass.gov/dep/cleanup/laws/0974_2.htm.

3. EPA, 2002, Draft Guidance for Evaluating the VI to Indoor Air Pathway from Groundwater and Soils http://www.epa.gov/osw/hazard/correctiveaction/eis/vapor/complete.pdf, using target risk levels of $1x10^{-6}$ excess lifetime cancer risk and noncancer hazard quotient of 0.1 in accordance with best practices for vapor intrusion screening to account fo cumulative effects from multiple chemicals. Values updated using May 2012 Regional Screening Levels (Residential Indoor Air) for Chemical Contaminants at Superfund Sites http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm.

* VOC data available only, no EPH/VPH analysis was conducted at this location.

-- = not applicable, no detections were reported during analysis of this sample.

Screening values shown (both the MassDEP MCP Method 1 Groundwater-2 screening values and generic unrestricted groundwater screening values) are summarized in Table 4-1 of the main document.

Results in bold exceed a VI screening value.

Key:

BRL = below reporting limit	MassDEP = Massachusetts Department of Environmental Protection
DL = detection limit	MW = monitoring well sample
EPA = United States Environmental Protection Agency	NE = not established
EPH = extractable petroleum hydrocarbons	RL = reporting limit
ft msl = feet mean sea level	VI COPC = Vapor Intrusion Contaminant of Potential Concern
GW-2 = MCP Method 1 GW-2 groundwater standard	VOC = volatile organic compound
J = estimated concentration	VPH = volatile petroleum hydrocarbon
MCP = Massachusetts Contingency Plan	µg/L = micrograms per liter

Table P-2
FTA-2 Area Monitoring Well Construction Information
Final 2011 MMR Vapor Intrusion Evaluation Technical Memorandum

Location	Northing (ft)	Easting (ft)	Surface Elevation (ft msl)	Measuring Point Elevation (ft msl)	Total Well Depth (ft bgs)	Top Screen Depth (ft bgs)	Bottom Screen Depth (ft bgs)	Top Screen Elevation (ft msl)	Bottom Screen Elevation (ft msl)	Screen Length (ft)
05MW0001	237957	863373	109.09	111.58	67	56.50	66.50	52.59	42.59	10
05MW0002	238584	863658	110.41	112.82	63	53.00	63.00	57.41	47.41	10
28MW0004	239586	864723	111.76	114.20	62	52.00	62.00	59.76	49.76	10
28MW0005	239249	864218	108.66	111.50	61	51.00	61.00	57.66	47.66	10
28MW0006	239034	864807	109.25	111.71	64	51.80	61.80	57.45	47.45	10
28MW0009	239768	864763	111.89	114.62	64	53.50	63.50	58.39	48.39	10
28MW0011	239333	864878	110.90	113.44	63	53.00	63.00	57.90	47.90	10
28MW0013	239327	864946	112.07	115.14	63	53.00	63.00	59.07	49.07	10
28MW0014	239115	864619	96.08	98.92	49	44.00	49.00	52.08	47.08	5
28MW0016	238623	864062	96.79	99.42	50	40.00	50.00	56.79	46.79	10
28MW0017	238467	864422	99.38	102.34	53	43.00	53.00	56.38	46.38	10
28MW0022	237103	863963	97.29	100.01	60	50.00	60.00	47.29	37.29	10
28MW0023	236929	864213	104.77	107.76	66	56.00	66.00	48.77	38.77	10
28MW0104	239489	864270	110.51	112.99	62	52.00	62.00	58.51	48.51	10
28MW0105	239366	863957	111.64	113.89	63	53.00	63.00	58.64	48.64	10
28MW0106	239276	864133	109.21	111.25	61	51.00	61.00	58.21	48.21	10
28MW0597C	237928	865035	105.74	105.33	62	57.10	62.10	48.64	43.64	5
28MW0598B	237308	864797	107.16	106.90	62	57.00	62.00	50.16	45.16	5
39DP0101	238916	864296	103	NA	NA	NA	NA	NA	NA	NA
39DP0102	237278	864112	96	NA	NA	NA	NA	NA	NA	NA
39DP0103	236790	864212	102	NA	NA	NA	NA	NA	NA	NA
39MW0001	237916	863979	94.20	96.99	47	37.40	47.40	56.80	46.80	10
39MW0002	238522	864230	98.32	100.47	56	46.10	56.10	52.22	42.22	10
39MW0003	238045	864179	94.60	97.25	50	40.00	50.00	54.60	44.60	10
39MW0004	238090	864259	95.70	98.11	46	43.10	45.50	52.60	50.20	2
39MW0005	237934	864241	98.12	100.44	50	46.00	51.00	45.67	50.67	5
39MW0006	237335	864407	105.28	104.92	60	54.80	59.80	50.48	45.48	5
39MW402A	237974	864296	95.91	94.13	50	40.00	50.00	55.91	45.91	10
39MW404A	237862	864218	99.52	97.46	54	44.00	54.00	55.52	45.52	10
39MW405A	237836	864298	90.72	95.18	50	40.00	50.00	50.72	40.72	10
39MW407A	237992	864176	93.35	90.23	54	44.00	54.00	49.35	39.35	10
39MW408A	237979	864249	95.14	96.92	58	43.00	58.00	52.14	37.14	15
39MW409A	237869	864275	98.73	96.80	58	43.00	58.00	55.73	40.73	15
39MW410A	237777	864275	100.05	98.82	54	44.00	54.00	56.05	46.05	10
39MW411A	237794	864309	98.87	98.51	54	44.00	54.00	54.87	44.87	10

Data Source: AFCEE, April 2012, MMR-AFCEE Data Warehouse

Key:

bgs = below ground surface

ft = feet

msl = mean sea level

NA = Not Applicable - locations are direct push vertical profile borings and have no permanent screens.